MONTHLY WEATHER REVIEW.

Editor: Prof. CLEVELAND ABBE. Assistant Editor: CLEVELAND ABBE, jr.

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The MONTHLY WEATHER REVIEW summarizes the current manuscript data received from about 3,500 land stations in the United States and about 1,250 ocean vessels; it also gives the general results of the study of daily weather maps based on telegrams or cablegrams from about 200 North American and 40 European, Asiatic, and oceanic stations.

The hearty interest shown by all observers and correspondents is gratefully recognized.

Acknowledgment is also made of the specific cooperation of the following chiefs of independent, local, or governmental services: R. F. Stupart, Esq., Director of the Meteorological Service of the Dominion of Canada; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. I. S. Kimball, General Superintendent of the United States Life-Saving Service; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; W. N. Shaw, Esq., Director Meteorological Office, London; Maxwell Hall, Esq., Government Meteorologist, Kingston, Jamaica; Rev. L. Gangoiti, Director of the Meteorological Observatory of Belen Collegel Havana, Cuba; Luis G. y Carbonell, Director, Meteorologica, Service of Cuba, Havana, Cuba; Rev. José Algué, S. J., Director of the Weather Bureau, Manila Central Observatory, Philippines; Maj. Gen. M. A. Rykachef, Director of the Physical Central Observatory, St. Petersburg, Russia; Carl Ryder, Director, Danish Meteorological Institute, Copenhagen, Denmark.

As far as practicable the time of the seventy-fifth meridian is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

FORECASTS AND WARNINGS.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

During the last seven days of September a hurricane advanced from the Lesser Antilles of the West Indies to the Great Bahama Bank. During October 1 the vortex of the hurricane recurved northward over the western Bahamas. The following notes regarding this storm are from the Nassau, New Providence Island, Bahamas, Guardian of October 3, 1908:

> The first intelligence that another hurricane had made its appearance reached us last Saturday (September 26), when we were informed by cable from Washington that a storm was central near and south of Porto Rico moving westnorthwest. This information was confirmed by telegrams from the same source dated the 28th, 29th, and 30th, stating that a hurricane was central near the eastern extremity of Cuba, and finally that a hurricane was central near the great Bahama Bank moving west-northwest. These statements were entirely borne out by the weather here on September 30, which throughout the day wore an exceedingly threatening aspect. * * * By 8 a. m. of October 1 the barometer had fallen to 28.88 inches, while the wind southeast had risen to an estimated velocity of 80 miles an hour—estimated, because at 7:45 a. m. the wind-recording instruments at the Observatory were blown away. At this time squall succeeded squall with rapidly increasing velocity from the southeast, the rain falling in continuous torrents, being driven by the wind with a force that the few adventurous persons who were out found positively blinding. * * * Although much damage was done on land, interest centered on the shipping in the harbour, most of which was in sore straits. * * * At 10 a. m. the barometer reached a minimum of 28.68 inches with wind from the south blowing at an estimated velocity of 60 to 80 miles an hour. At noon the barometer had risen to 29.10 inches.
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> An instance of the value of the storm telegrams is afforded by information obtained from Mr. Wm. Hilton, who arrived this morning from Staniard Creek. He states that a great many of the sponging craft there had been launched and taken out of the creek to the North Side, but that on the receipt by the Rev. Mr. Dinsdale, on Sunday night, of a copy of Saturday's storm telegram, sent by the Port Officer, the vessels were all brought into the creek again and secured. Had this not been done the damage to shipping there would probably have been very great.

The telegrams referred to were sent by the Chief of the Weather Bureau to the Governor of the Bahamas, Nassau. They were begun September 26, 1908, and advised measures to protect shipping.

From the western Bahamas the storm recurved to the eastward over the Atlantic. During the 3d and 4th severe gales were experienced on the northeast coast of Cuba, and on the 6th a disturbance that was probably a continuation of the Bahamas hurricane past near Bermuda with a reported barometric pressure of 29.22 inches. After passing Bermuda the storm moved on a north of east course, and on the 6th the meteorological observatories at Horta, Fayal, Azores, and Lloyds, London, were advised regarding its character and probable course over the ocean. A forecast was also made that the storm would pass near and north of the Azores by the night of the 7th and reach the middle-western European coasts by the 9th. During the 7th the barometer fell to 29.66 inches at Horta and then rose rapidly to 30.16 by the morning of the 8th with wind shifting from southwest to northwest. During the succeeding two days the storm apparently moved northeastward and past near and west of the British coasts. On the morning of the 9th it was central northwest of Scotland.

On the 4th, when this storm occupied the subtropical waters of the Atlantic north of the West Indies, a typhoon is reported to have visited the Island of Luzon, P. I.

During this storm period over the Atlantic the weather was unseasonably cool over the interior of the United States, and snow fell in the early part of the first decade of the month in the northern Rocky Mountain districts. The barometric depressions that appeared over the North American Continent possest slight intensity. It has been observed that in the presence over the western Atlantic of disturbances of tropical or subtropical origin the intensity of storms over the interior of the American Continent decreases as they advance eastward.

During the 8th a shallow barometric depression that had covered Cuban and Florida waters for several days moved northward over the South Atlantic States. On this date also the presence of a typhoon over the Philippine Islands was indicated by the Manilla report. From the 8th to 11th the southeastern depression moved slowly over the Atlantic seaboard of the United States, and a disturbance from the British Northwest Territory advanced over the Lake region and St.

Lawrence Valley. Following the unsettled rainy weather that attended these disturbances an area of high barometer and cool, fair weather moved from the British Northwest Territory eastward and southeastward to the Atlantic and Gulf States, attended by freezing temperature as far south as northwestern Arkansas on the 13th and 14th, and by the first heavy frost of the season in the Middle Atlantic States.

Following this cool period a warm wave carried temperatures 10° to 20° above the seasonal average in middle and northern districts from the Rocky Mountains to the Atlantic coast. The warm wave resulted from abnormally low barometric pressure that existed for several days, beginning October 10, over the northern Pacific Ocean and adjacent parts of the American Continent. This distribution of pressure caused a strong flow of air currents from the warmer latitudes over the interior of the continent. The increasing warmth imparted by these currents to air overlying the region from the Great Plains eastward also contributed to the period of dry weather that began in the middle and northern districts east of the Rocky Mountains about October 11 and continued until about the middle of the third decade of the month.

Note was made in the general forecast of the evening of the 12th that a typhoon was approaching the Island of Luzon, P. I., from the east that would probably strike the Chinese coast near the Island of Hongkong. This storm was very severe over the northern portion of Luzon on the 12th and two days later it struck with destructive force the region about Amoy and Chang-chow, to the northward of Hongkong. This storm was encountered by the American battleship fleet off the north coast of Luzon during October 12 and 13 and there reached its height on the morning of the 13th.

From the 16th to 18th an area of high barometer moved from the interior of British America southward over the Rocky Mountain and Plains States and past thence eastward during the 19th and 20th over the Great Lakes, New York, and New England. From the 14th to 16th a depression crost the Pacific States attended by the first rain of the season over the northern half of California. From the 18th to 20th a deep barometric depression moved northward along the eastern Rocky Mountain slope and on the morning of the 20th a barometer reading of 28.98 inches was reported at Williston, N. Dak. This depression, in conjunction with the preceding high-barometer area, caused general precipitation from the Mississippi River over the Rocky Mountain and Plateau districts, that in the mountain districts and the Northwest was in the form of snow.

On Tuesday, October 20, the following general forecast was issued:

> The barometer has fallen rapidly over the southern Rocky Mountain region, and a well-defined storm will appear in that section Wednesday morning. This storm will move northeastward, attended by rain in the central valleys Thursday, and in the Atlantic States Friday or Saturday. The rains promise to be sufficiently heavy to extinguish the fires in the Allegheny and Adirondack mountains.

The rains set in as forecast, and in the eastern mountain districts, where forest fires were destroying property, they continued several days.

From the 19th to the 23d a period of exceptionally cool weather attended the presence of an area of high barometric pressure over continental Europe. Temperatures in Germany were reported the lowest experienced in October since 1866.

On the 21st and 22d, when the central portion of an area of high barometric pressure occupied the Middle Atlantic States, the kites at Mount Weather penetrated a stratum of relatively warm air half a mile above the station. On the following day the mountain was enveloped in a dense fog, with upper currents strong enough to crush the first kite that was sent up. These strong easterly currents flowed from the southern quadrants of an area of high barometer that was moving off the north Atlantic coast, thru the north quadrants of a low-pressure area that occupied the south Atlantic coast and toward a low area over Arkansas. This strong drift of air apparently carried the low-pressure area of the south Atlantic coast inland where it united on the 24th with the Arkansas low area that had moved northward to the upper Mississippi Valley. The upper currents in this case indicated at least a day in advance, the abnormal movement of the southeastern disturbance.

From the 28th to 30th a tropical disturbance, that had apparently advanced from the western portion of the Caribbean Sea, past from the eastern portion of the Gulf of Mexico northeastward along the Atlantic coast of the United States, attended by heavy rain and gales. During these dates an area of cool weather and frost advanced from the west Gulf States over the east Gulf and South Atlantic States. It is probable that the storm of the 28–30th was identical with a disturbance that visited the Central American coasts and Yucatan and past thence over the Gulf of Mexico.

October closed with fair weather, except over the extreme northwestern portions of the country, and temperature below the seasonal average from the central valleys over the Atlantic States.

BOSTON FORECAST DISTRICT.*

[New England.]

The month was warmer than usual and, except in localities in Rhode Island and eastern Massachusetts, precipitation was deficient. Light snow fell in all parts of New England, the greatest fall of the month, 1.2 inches, occurring at Bloomfield, Vt. During the second and third weeks of the month the atmosphere was thick with smoke, and in some instances the density of the smoke retarded the movements of vessels. In the northern States there was considerable damage from forest fires. At the close of the month streams and springs were dry and there was great need of general and heavy rains. A storm of unusual severity occurred on the 29–30th. There were no storms without warnings. Frost warnings were issued to cranberry growers on the 3d and 12th and, it is believed, with much benefit to the cranberry interests.—*J. W. Smith, District Forecaster.*

NEW ORLEANS FORECAST DISTRICT.*

[Louisiana, Texas, Oklahoma, and Arkansas.]

Precipitation was deficient, except in Oklahoma and the northwestern portion of eastern Texas where exceptionally heavy rains fell during the early portion of the third decade of the month. Cool weather for the season prevailed and frost occurred in the northern portion of the district on eleven dates. The usual frost warnings were issued, and no warnings were issued for dates on which frost did not occur. There were no general storms on the coast and no storm warnings were issued.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

Severe drought prevailed thruout the month, except in a portion of eastern Tennessee. Temperature averaged about normal. Frost was frequent the first and last parts of the month. On the 31st frost was general and heavy in Tennessee and killing in Kentucky. Warnings were issued in advance of the occurrence of all important frosts.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

The weather thruout the month was uneventful, except as regards the continuation of the drought which broke with the general rains of the 18–25th. No storms that seriously affected navigation on the Lakes occurred.—*H. J. Cox, Professor and District Forecaster.*

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

The feature of the month was the heavy precipitation in western Wyoming, northwestern Colorado, and the eastern counties of Colorado. In the plains region of Colorado the rainfall was excessive on the 18th and 19th. Considerable damage by flood was caused in the southeastern portion of the State by the overflow of the Arkansas River below the mouth of the Picketwire. Warnings of the flood were issued on the morning of the 19th. Temperature averaged lower than usual thruout the district.—*F. H. Brandenburg, District Forecaster.*

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

The month as a whole was one of pleasant weather, with rather less rain than usual. There were no especially noteworthy features.—*A. G. McAdie, Professor and District Forecaster.*

PORTLAND, OREG., FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

Temperature was slightly below the normal, and precipitation, except in a few localities, was in excess of the normal. Frosts in the western sections, altho not more frequent, were heavier than usual. There were three storm periods, but the winds attending them were not severe. The warnings for high winds were timely and beneficial, and warnings were issued for all important frosts.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

The drought conditions that persisted during the first three weeks of the months over the middle and northern districts east of the Rocky Mountains held the rivers to their abnormally low stages, and the effects of the rains that fell late in the month were scarcely noticeable. As in September, the effects of the drought were most noticeable in the Ohio River where there was no hope of an early resumption of navigation. At Parkersburg, W. Va., the low-water stage of —0.3 foot was the lowest on record.

There was a moderate flood in the upper Arkansas River, beginning on the 19th in southeastern Colorado, and reaching Wichita, Kans., on the 23d. At the same time there was a decided rise in the lower Arkansas River and its tributaries, with flood stages in the Neosho River, and in the Arkansas in the vicinity of Fort Smith, Ark. At the end of the month the lower river was still rising, but with no prospect of serious flood. Warnings were issued wherever possible and they were, as usual, valuable and timely.

These floods were caused by heavy rains that extended over eastern Colorado, Kansas, and Oklahoma, beginning on the 18th in Colorado, and reaching a maximum in Oklahoma and eastern Kansas from the 20th to the 22d, inclusive. In the State of Oklahoma, where the rainfall was probably heaviest, the floods were more pronounced and great damage was done; the losses will probably run into millions, but it has thus far been impossible to obtain detailed estimates. Effort will be made, however, to secure data for publication in a later edition of the MONTHLY WEATHER REVIEW.

On the Neosho and lower Arkansas rivers the damage was small, probably amounting to not more than $25,000.

The heavy rain area extended also into northern Texas, causing a moderate rise in the upper Trinity River; due notice was given and no damage resulted.

Heavy rains in South Carolina on the 22d and 28th were followed by rapid rises in all the rivers of the State; the floods were moderate. Warnings were issued promptly and no damage of consequence resulted.

The highest and lowest water, mean stage, and monthly range at 208 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

* Morning forecasts made at district center; night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

DEFLECTING FORCE DUE TO THE EARTH'S ROTATION.

By R. A. HARRIS. Dated Washington, D. C., September 1, 1908.

In connection with Mr. Okada's recent paper[1] it may be of interest to show how the deflecting force can be obtained by aid of the usual two-dimensional expressions for the acceleration resolved along and perpendicular to the radius vector.

If a material point move in any plane curve, and if ρ and ψ denote its polar coordinates, then the acceleration along ρ increasing will be

$$\text{Acceleration}_\rho = \frac{d^2\rho}{dt^2} - \rho\left(\frac{d\psi}{dt}\right)^2,$$

and that perpendicular to ρ, ψ increasing, will be

$$\text{Acceleration}_\psi = \rho\frac{d^2\psi}{dt^2} + 2\frac{d\rho}{dt}\frac{d\psi}{dt}.$$

These fundamental expressions are readily obtained either by considering the velocities resolved with reference to polar coordinates at two successive instants of time, or by combining accelerations along the x and y directions, the same having been first exprest in polar coordinates.

Next suppose this plane to be tangent to a sphere, the moving point marking, or coinciding with, the point of contact for the short interval considered. Let r, θ, and φ, denote the polar coordinates of this point (θ being north polar distance and φ east longitude from a meridian fixt in space), and let the origin of its plane coordinates (ρ, ψ) be taken at the point where the axis of the sphere from which θ is reckoned pierces the tangent plane; then

$$\rho = r\tan\theta, \quad d\rho = r\,d\theta;$$

$$d\psi = \frac{r\sin\theta}{r\tan\theta}d\varphi = \cos\theta\,d\varphi.$$

Now suppose the velocity along the path to be uniform for the short time considered.

$$\text{Acceleration}_\theta = -r\sin\theta\cos\theta\left(\frac{d\varphi}{dt}\right)^2 = -\frac{\cos\theta}{r\sin\theta}v_\phi^2$$

$$\text{Acceleration}_\phi = 2r\cos\theta\frac{d\theta}{dt}\frac{d\varphi}{dt} = 2\frac{\cos\theta}{r\sin\theta}v_\phi v_\theta$$

where, of course, the velocities are absolute velocities in space.

On the earth, which rotates from west to east with an angular velocity k_1, we have

$$v_\theta = v_s$$
$$v_\phi = r\,k_1\sin\theta + v_e,$$

where v_s and v_e denote velocities relative to the earth's surface.

Hence, acceleration$_\theta$ of particle moving with reference to the earth's surface — acceleration$_\theta$ of particle at rest upon the earth's surface $= -2k_1v_e\cos\theta$.

Similarly, Acceleration$_\phi = 2k_1v_s\cos\theta$.

Hence, the material point is capable of exerting deflecting forces such that

[1] Monthly Weather Review, May, 1908, XXXVI, p. 147.

$$\text{Southward force} = 2k_1 v_e \cos\theta.$$
$$\text{Eastward force} = -2k_1 v_s \cos\theta.$$
$$\text{Hence, Total force} = 2k_1 v \cos\theta.$$

The tangent of the direction of the action of this force (from south via east) is

$$-\frac{v_s}{v_e} = \frac{v_s}{v_w},$$

while the tangent of the direction of the moving particle is, of course,

$$-\frac{v_e}{v_n} = \frac{v_e}{v_s}.$$

The force, therefore, acts at right angles to the instantaneous path of the particle, and so is a deflecting force. (*Cf.* Coast and Geodetic Survey Reports, 1900, p. 571; 1904, p. 332.)

STUDIES ON THE VORTICES OF THE ATMOSPHERE OF THE EARTH.

By Prof. FRANK H. BIGELOW. Dated Washington, D. C., March 16, 1908.

IV.—THE DEWITTE TYPHOON, AUGUST 1-3, 1901.

THE METEOROLOGICAL DATA.

In order to illustrate the structure of a hurricane as analyzed by the theory of the dumb-bell-shaped vortex, I have chosen the DeWitte typhoon which occurred in the China Sea August 1-6, 1901. This hurricane is specially valuable for our studies, because the observations at observatories on the coast of China and on the outlying islands afford an unusually large amount of suitably published data. A paper by Rev. Louis Froc, S. J.,[1] and some notes by Rev. José Algué, S. J.,[2] give the isobars, wind directions and velocities at midnight of August 2, 1901. In Table 52 will be found other data extracted from the China Coast Meteorological Register and the Monthly Report of the Central Meteorological Observatory of Japan.

The isobars of August 2, 10 a. m., 10 p. m., August 3, 5 a. m., are reproduced in Chart IX, figs. 9, 10, and 11, respectively. The isobars of August 2, 10 p. m., fig. 10, have been made the basis of the computation, because the typhoon was then at its greatest intensity, the barometer at the center having fallen to about 690 millimeters. Chart IX, fig. 12, shows upon an adopted system of isobars constructed from the vortex data, the wind direction and velocity located according to circumstances within the diagram so as to give a composite view of the vectors on all sides of the axis and at the proper distances from it. The temperatures, fig. 13, and the relative humidity, fig. 14, have been plotted in a similar manner. An inspection of the temperature and relative humidity diagrams, shows that in this case there is no important difference between the western and the eastern quadrants, such as is always found in ordinary cyclones as distinguished from hurricanes. The relative humidity, however, seems to be somewhat higher in the southwest quadrant than in the others, due probably to the excess of the tendency to precipitation in that region. It is very evident that no temperature differences exist in the sea-level horizontal section of the hurricane, such as can account for its energy thru rotations generated by two masses at different temperatures lying side by side on the same level. It is probable that these temperature differences exist in higher levels where a cold sheet overlays a warm sheet, the surface of separation being horizontal rather than vertical.

CONSTRUCTION OF THE AVERAGE HURRICANE VORTEX.

It is our purpose to construct the average vortex which underlies the actual hurricane with all its divergencies due to local conditions. The vortices in the atmosphere are seldom symmetrical, tho the principles of vortex action prevail with more or less perturbation. It is our first study to obtain the symmetrical vortex with all its velocities, angles, and pressures; we can then find the forces which produce the actual vortex, thru a series of differences obtained by subtracting the symmetrical system from the observed data. Thus the progressive northwestward motion of the typhoon makes the wind-angles greater southwest of the center than to the northwest. This angular difference is eliminated as follows: At the northern, eastern, southern, and western points of each isobar construct the appropriate wind vector (the heavy dotted arrows of fig. 12) as accurately as possible from the wind observations taken in the region and plotted on the composite diagram, fig. 12. Then take the mean velocity and the mean angle on each isobar, i. e., the mean values of the four average vectors of each isobar. In the present study the angle 30° has been assumed thruout this horizontal section, whence $i = -30°$ and $az = 60°$, the angular height at which the general vortex is truncated by the sea-level plane, whatever its actual height in meters may be.

TABLE 52.—*Meteorological data*[3] *of the De Witte typhoon, August 1-3, 1901.*

Station.	Latitude North.	Longitude East.	Date.	Hour.	*B.*	*t.*	Relative humidity.	Wind.	
	°	°			*Mm.*	°*C.*	*Percent.*	*M.p.s.*	*Dir.*
Gutzlaff	30.49	122.10	Aug. 1	3 p.m.	757.2	28.9	87	7	ese.
			2	9 a.m.	754.9	26.7	80	11	ene.
			2	3 p.m.	......	......	......	......	......
			3	9 a.m.	750.8	26.1	95	25	ese.
Sharp Peak	26.7	119.40	Aug. 1	3 p.m.	753.1	28.9	85	11	ne.
			2	9 a.m.	748.3	30.0	86	7	nnw.
			2	3 p.m.	743.5	32.3	91	7	nnw.
			3	9 a.m.	728.5	26.7	78	25	ssw.
Amoy	24.27	118.5	Aug. 1	3 p.m.	753.9	31.6	80	9	se.
			2	9 a.m.	751.1	28.3	83	7	wsw.
			2	3 p.m.	747.5	34.4	94	9	w.
			3	9 a.m.	742.2	30.3	96	16	sw.
Taihoku	25.4	121.28	Aug. 1	10 p.m.	750.4	26.8	91	4	nw.
			2	10 a.m.	742.6	26.2	93	21	nw.
			2	10 p.m.	732.7	24.3	99	27	nw.
			3	5 a.m.	736.8	25.2	86	17	sw.
Taichu	24.2	120.40	Aug. 1	10 p.m.	744.9	25.1	91	4	n.
			2	10 a.m.	738.7	26.1	93	16	nw.
			2	10 p.m.	736.3	24.1	98	6	n.
			3	5 a.m.	734.4	26.9	97	15	sw.
Hokoto	23.33	119.34	Aug. 1	10 p.m.	751.7	28.0	85	10	nw.
			2	10 a.m.	747.6	29.5	76	16	nw.
			2	10 p.m.	742.5	28.8	87	12	wsw.
			3	5 a.m.	740.5	28.6	91	17	nw.
Tainau	22.59	120.12	Aug. 1	10 p.m.	750.2	28.1	80	6	nw.
			2	10 a.m.	746.3	28.8	71	12	nw.
			2	10 p.m.	742.7	25.9	100	10	w.
			3	5 a.m.	742.1	28.2	87	17	sw.
Taito	22.45	121.8	Aug. 1	10 p.m.	747.3	27.4	76	4	w.
			2	10 a.m.	739.8	26.0	92	8	sw.
			2	10 p.m.	738.5	27.4	74	21	ssw.
			3	5 a.m.	739.7	27.3	87	17	sw.
Ishigakijima	24.20	124.7	Aug. 1	10 p.m.	740.6	25.8	93	17	n.
			2	10 a.m.	725.5	26.0	100	22	n.
			2	10 p.m.	737.2	27.0	91	37	s.
			3	5 a.m.	744.7	28.7	83	26	s.
Naba	26.13	127.41	Aug. 1	10 p.m.	741.0	25.6	83	21	e.
			2	10 a.m.	742.5	25.5	91	24	ese.
			2	10 p.m.	751.5	26.8	90	10	se.
			3	5 a.m.	752.6	26.5	83	9	se.
Oshima	28.23	129.30	Aug. 1	10 p.m.	753.6	27.9	80	4	e.
			2	10 a.m.	753.7	28.0	76	14	se.
			2	10 p.m.	757.4	27.4	80	10	se.
			3	5 a.m.	758.0	26.6	85	7	ese.

For the mean isobars of the vortex the procedure is as follows: Scale off the distance of the isobars from the center on the north, east, south, and west lines and take the mean of these four as the observed radius, ϖ, of the appropriate vortex tube. Look out the log ϖ of the successive radii and take the successive differences, $\log \rho = \log \varpi_n - \log \varpi_{n+1}$. Finally, take the mean, $\log \rho_m$, and reconstruct the computed $\log \varpi_n$ by

[1] The DeWitte Typhoon, August 1-6, 1901. Annals Zi-ka-wei Observatory.

[2] The Cyclones of the Far East. Manila Observatory. p. 31.

[3] Extracted from the China Coast Meteorological Register and the Monthly Report of Central Meteorological Observatory of Japan.

adding log ρ_m to the inner radius, which in this typhoon is assumed to be $\varpi_8=14{,}000$ meters. On the scale of the diagram, fig. 13, 1° of the map = 96,000 meters. The value of the mean log ρ_m is smaller for August 2, 10 p. m., than for August 1, 10 a. m., or August 3, 5 a. m., and the diagrams, figs. 9, 10, and 11, show that the isobars are closer on August 2, 10 p. m., than on the preceding or the following dates. The probable pressures, B, radial distances ρ of the isobars in meters and in ϖ_n have been placed on the diagrams, figs. 12, 13, 14, in their northeast quadrants.

In Table 53 will be found the mean measured radii of the several isobars. The inner radii were found by constructing diagrams in two coordinates with B_n and ϖ_n as arguments and drawing a suitable curve to represent both elements. From log ϖ is computed log ρ and log ρ_m, and beginning with $\varpi_8=14{,}000$ meters the other radii are constructed by adding log ρ_m in succession. This table also compares the computed ϖ_n with the adopted ϖ_n as derived from the diagrams. In computing the values of u and v, after a few velocities are derived from the observations, the values of v can be extended to the outer and inner tubes without direct velocity readings, since $v\varpi=$ constant, $v=q\cos 30°$, $u=-q\sin 30°$.

TABLE 53.—*The observed and adjusted values of ϖ in the De Witte typhoon.*

B.	Tube.	Measured.		log ρ.	Adjusted.	
		ϖ.	log ϖ.		log ϖ.	ϖ.
Mm.		*Meters.*				*Meters.*
690	ϖ_8	14000	4.14613		4.14613	14000
				0.19629		
700	ϖ_7	22000	4.34242		4.35159	22470
				0.22578		
710	ϖ_6	37000	4.56820		4.55705	36062
				0.23798		
720	ϖ_5	64000	4.80618		4.76251	57878
				0.16230		
730	ϖ_4	93000	4.96848		4.96797	92890
				0.21904		
740	ϖ_3	154000	5.18752		5.17343	149830
				0.19269		
750	ϖ_2	240000	5.38021		5.37889	239272
				0.20412		
760	ϖ_1	384000	5.58433		5.58435	384018
			Mean log ρ=0.20546			

Table 54 contains the computation of the values of ϖ, u, v, and w on the sea-level plane for $az=60°$. The only point that needs special consideration is the adopted value of a, the angular constant, as the top of the hurricane is assumed to be in the level 12,000 meters above the sea. Two general reasons lead to this assumption. First, the approach of a hurricane is always heralded by *high cirrus* clouds flying away radially from the center, and in the Tropics this implies an elevation of from 10,000 to 12,000 meters. Second, in the discussion of the hurricane in the International Cloud Report,[4] it was shown that the characteristic disturbance of the atmosphere as evidenced by the high cloud motions, reaches the cirrus with decided strength. It is probable that the upper asymptotic plane of the vortex system is at the 12,000 meters-level, and that the lower asymptotic plane is 6,000 meters below sea-level, so that,

$$a=\frac{180°}{12{,}000+6{,}000}=\frac{180°}{18{,}000}=0.010°.$$

This is the value of the constant adopted for hurricanes and it is one-tenth as large as the corresponding one for the St. Louis tornado. It may be possible to determine these constants, log ρ_m and a, more accurately in the future and then our computations can be made with greater precision.

COMPUTATION OF ϖ, u, v, w, ON OTHER PLANES.

The values of log $a\varpi\sin az$, log A, log u, log w on the 60° plane, as given in Table 54, now follow from the formula and it is only necessary to extend the computations for ϖ, u, v, and w to the other levels, as will be found in Tables 56, 57, 58, and 59. It is necessary to proceed by logarithms thruout for the sake of precision in working with the large numerical values involved. Since some care must be taken to produce log $Aa\varpi$ correctly in the other levels we give this part of the work in full. By the formula for the radius,

$$\varpi^2=\frac{\psi}{A\sin az},$$

we first compute ψ from the formula

$$\psi=\frac{v\varpi}{a},$$

and this is easily done since the terms are known. We obtain from Table 54, for tube (1), the constants $\log\psi=\log\frac{v\varpi}{a}=8.41069$, $\log A=7.30446$, $\log a=8.00000-10$.

TABLE 54.—*Computation of ϖ, u, v, w, for each radius, ϖ_n, on the sea-level plane, $az=60°$.*

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Observed u	−3.7	−5.5	−10.0	−15.0	−22.0	−37.0	....	....
Observed v	7.0	11.0	17.0	25.0	41.0	72.0	130.0	....
log v	0.84510	1.04139	1.23045	1.39794	1.61278	1.85733	2.11394	....
log ϖ	5.58435	5.37889	5.17343	4.96797	4.76251	4.55705	4.35159	4.14613
log $v\varpi$	6.42945	6.42028	6.40388	6.36591	6.37529	6.41438	6.46553	....
mean log $v\varpi$	=log $a\psi$=6.41069							
log v	0.82634	1.03180	1.23726	1.44272	1.64818	1.85364	2.05910	2.26456
v	6.70	10.76	17.27	27.72	44.48	71.39	114.58	183.89

$a=\frac{180}{12000+6000}=0.010°$ $az=60°$ $z=12000.$

$\log a=\log 0.010=8.00000$ $\log\sin 60°=9.93753$, $\log\cos 60°=9.69897$

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log $a\varpi\sin az$	3.52188	3.31642	3.11096	2.90550	2.70004	2.49458	2.28912	2.08366
log A	7.30446	7.71538	8.12630	8.53722	8.94814	9.35906	9.76998	0.18090
A	.002016	.005193	.013375	.034452	.088744	.248922	.588814	1.516690
log $Aa\varpi$	0.88881	1.09427	1.29973	1.50519	1.71065	1.91611	2.12157	2.32703
log u	−0.58778	−0.79324	−0.99870	−1.20416	−1.40962	−1.61508	−1.82054	−2.02600
u	−3.87	−6.21	−9.97	−16.00	−25.68	−41.22	−66.15	−106.17
log w	7.54302	7.95394	8.36486	8.77578	9.18670	9.59762	0.00854	0.41946
w	.0035	.0090	.0232	.0597	.1537	.3959	1.0199	2.6210

TABLE 55.—*Computation of log ϖ and $Aa\varpi$ for all levels of tube (1).*

Altitude.	$\log\frac{\psi}{A\sin az}$	log ϖ	log $Aa\varpi$	log sin az	log cos az
°					
$az=90$	11.10623	5.55311	0.85757	0.00000	$-\infty$
80	11.11288	5.55644	0.86090	9.99335	9.23967
70	11.13324	5.56662	0.87108	9.97299	9.53405
60	11.16870	5.58435	0.88888	9.93753	9.69897
50	11.22198	5.61099	0.91545	9.88425	9.80807
40	11.29816	5.64908	0.95454	9.80807	9.88425
30	11.40726	5.70363	1.00806	9.69897	9.93753
20	11.57218	5.78609	1.09055	9.53405	9.97299
10	11.86656	5.93328	1.23774	9.23967	9.99335
0	$+\infty$	$+\infty$	$+\infty$	$-\infty$	0.00000

General formulas.

$$a\psi=Aa\varpi^2\sin az.$$
$$u=-Aa\varpi\cos az.$$
$$v=Aa\varpi\sin az.$$
$$w=2A\sin az.$$
$$a\psi=v\varpi.$$
$$\tan i=-\cot az=\frac{u}{v}.$$
$$\tan\eta=\frac{w}{v\sec i}.$$
$$q=v\sec i\sec\eta.$$

[4] See Report Chief of Weather Bureau, 1898–99, vol. 2, p. 456.

The application of these general formulas leads to the values in Tables 56, 57, 58, 59, 60, 61, 62, and 63.

TABLE 56.—*Computation of log ϖ and the radius ϖ, for each tube at successive altitudes.*

Values of log ϖ.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az = 180°	∞	∞	∞	∞	∞	∞	∞	∞
170	5.93328	5.72782	5.52236	5.31690	5.11144	4.90598	4.70052	4.49506
160	5.78609	5.58063	5.37517	5.16971	4.96425	4.75879	4.55333	4.34787
150	5.70363	5.49817	5.29271	5.08725	4.88179	4.67633	4.47087	4.26541
140	5.64908	5.44362	5.23816	5.03270	4.82724	4.62178	4.41632	4.21086
130	5.61099	5.40553	5.20007	4.99461	4.78915	4.58369	4.37823	4.17277
120	5.58435	5.37889	5.17343	4.96797	4.76251	4.55705	4.35159	4.14613
110	5.56662	5.36116	5.15570	4.95024	4.74478	4.53932	4.33386	4.12840
100	5.55644	5.35098	5.14552	4.94006	4.73460	4.52914	4.32368	4.11822
90	5.55311	5.34765	5.14219	4.93673	4.73127	4.52581	4.32035	4.11489
80	5.55644	5.35098	5.14552	4.94006	4.73460	4.52914	4.32368	4.11822
70	5.56662	5.36116	5.15570	4.95024	4.74478	5.53932	4.33386	4.12840
60	5.58435	5.37889	5.17343	4.96797	4.76251	4.55705	4.35159	4.14613

Values of $\varpi = \left(\frac{a\psi}{Aa \sin az}\right)^{\frac{1}{2}}$.

az = 180°	∞	∞	∞	∞	∞	∞	∞	∞
170	857600	534338	332938	207443	129253	80534	50179	31265
160	611071	380742	237232	147813	92098	57384	35754	22278
150	505389	314900	196205	122250	76172	47460	29571	18425
140	445740	277727	173044	107820	67180	41858	26081	16250
130	408310	254406	158515	98766	61539	38344	23891	14886
120	384018	239272	149083	92890	57878	36062	22469	14060
110	368655	229700	143120	89174	55563	34619	21569	13440
100	360117	224379	139803	87108	54275	33818	21071	13129
90	357367	222663	138735	86444	53860	33559	20910	13028
80	360117	224379	139803	87108	54275	33818	21071	13129
70	368655	229700	143120	89174	55563	34619	21569	13440
60	384018	239272	149083	92890	57878	36062	22470	14060

THE VELOCITIES IN THE DE WITTE TYPHOON.

The lines on fig. 15 of Chart IX show that the maximum of the tangential velocity v is located in the level 3,000 to 4,000 meters above sea-level, which conforms to the facts obtained in the report on the international cloud observations regarding the distribution of the velocity v. The overhang of the upper portion of these lines agrees with the fact that radial outward velocities are first seen in the cirrus levels, 10,000–12,000 meters, and that they appear in advance of the high winds at the surface. Near the upper plane of reference the radial velocity, u, alone survives, and a moderate tendency for the air to flow out from a center over a large sheet will cause violent winds near the axis to supply the resulting losses, according to the vortex laws. If, in the general circulation, a cold sheet of air is brought to overlay a warm sheet, then the pressure difference, which would be discontinuous at the boundary plane, is partly compensated by the movement of the warm air outward in all directions beneath this cold sheet. This movement appears to be a primary cause of the generation of the vortex whose effect is felt at sea-level on the section which truncates it at the elevation $az = 60°$ where the inflowing angle $i = 30°$. The calm core is due to the violent centrifugal force near the axis, and it is here about 1,400 meters, or 9 miles, in diameter. The decreased pressure in this core favors a downpour from the higher levels, of air which warms and tends to clear the sky near the axis. It seems that this truncated vortex conforms to all the broad facts which are observed in connection with hurricanes and typhoons.

TABLE 57.—*Computation of radial velocities u, for each tube and altitude.*

Values of log u.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az = 180°	∞	∞	∞	∞	∞	∞	∞	∞
170	1.23109	1.43655	1.64201	1.84747	2.05293	2.25839	2.46385	2.66931
160	1.06354	1.26900	1.47446	1.67992	1.88538	2.09084	2.29630	2.50176
150	0.94554	1.15100	1.35646	1.56192	1.76738	1.97284	2.17830	2.38376
140	0.83779	1.04325	1.24871	1.45417	1.65963	1.86509	2.07055	2.27601
130	0.72352	0.92898	1.13444	1.33990	1.54536	1.75082	1.95628	2.16174
120	0.58778	0.79324	0.99870	1.20416	1.40962	1.61508	1.82054	2.02600
110	0.40513	0.61059	0.81605	1.02151	1.22697	1.43243	1.63789	1.84335
100	0.10057	0.30603	0.51149	0.71695	0.92241	1.12787	1.33333	1.53879
90	−∞	−∞	−∞	−∞	−∞	−∞	−∞	−∞
80	−0.10057	−0.30603	−0.51149	−0.71695	−0.92241	−1.12787	−1.33333	−1.53879
70	−0.40513	−0.61059	−0.81605	−1.02151	−1.22697	−1.43243	−1.63789	−1.84335
60	−0.58778	−0.79324	−0.99870	−1.20416	−1.40962	−1.61508	−1.82054	−2.02600

Values of $u = -Aa\varpi \cos az$.

az = 180°	∞	∞	∞	∞	∞	∞	∞	∞
170	17.03	27.32	43.86	70.38	112.96	181.30	290.97	466.99
160	11.58	18.58	29.82	47.85	76.80	123.27	197.83	317.51
150	8.82	14.16	22.72	36.47	58.53	93.94	150.77	241.97
140	6.88	11.05	17.73	28.46	45.67	73.30	117.64	188.80
130	5.29	8.49	13.63	21.87	35.10	56.34	90.42	145.12
120	3.87	6.21	9.97	16.00	25.68	41.22	66.15	106.17
110	2.54	4.08	6.55	10.51	16.86	27.07	43.44	69.72
100	1.28	2.02	3.25	5.21	8.36	13.42	21.54	34.58
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	−1.28	−2.02	−3.25	−5.21	−8.36	−13.42	−21.54	−34.58
70	−2.54	−4.08	−6.55	−10.51	−16.86	−27.07	−43.44	−69.72
60	−3.87	−6.21	−9.97	−16.00	−25.68	−41.22	−66.15	−106.17

TABLE 58.—*The computation of the tangential velocities for each tube and altitude.*

Values of log v.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az = 180°	−∞	−∞	−∞	−∞	−∞	−∞	−∞	−∞
170	0.47741	0.68287	0.88833	1.09379	1.29925	1.50471	1.71017	1.91563
160	0.62460	0.83006	1.03552	1.24098	1.44644	1.65190	1.85736	2.06282
150	0.70698	0.91244	1.11790	1.32336	1.52882	1.73428	1.93974	2.14520
140	0.76161	0.96707	1.17253	1.37799	1.58345	1.78891	1.99437	2.19983
° 130	0.79970	1.00516	1.21062	1.41608	1.62154	1.82700	2.03246	2.23792
60 120	0.82634	1.03180	1.23726	1.44272	1.64818	1.85384	2.05910	2.26456
70 110	0.84407	1.04953	1.25499	1.46045	1.66591	1.87137	2.07683	2.28229
80 100	0.85425	1.05971	1.26517	1.47063	1.67609	1.88155	2.08701	2.29247
90 90	0.85757	1.06303	1.26849	1.47395	1.67941	1.88487	2.09033	2.29579

Values of the tangential velocity, $v = Aa\varpi \sin az$.

az = 180°	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
170	3.00	4.82	7.73	12.41	19.92	31.97	51.31	82.34
160	4.21	6.76	10.85	17.42	27.95	44.86	72.00	115.56
150	5.09	8.17	13.12	21.06	33.79	54.24	87.04	139.70
140	5.78	9.27	14.88	23.88	38.32	61.50	98.71	158.43
° 130	6.31	10.12	16.24	26.07	41.84	67.14	107.76	172.95
60 120	6.70	10.76	17.27	27.72	44.48	71.39	114.58	183.89
70 110	6.98	11.21	17.99	28.87	46.34	74.36	119.35	191.55
80 100	7.15	11.47	18.42	29.55	47.43	76.13	122.18	196.10
90 90	7.20	11.56	18.56	29.78	47.80	76.71	123.12	197.60

TABLE 59.—*The computation of the vertical velocities w, for each tube and altitude.*

Values of log w.

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
az = 180°	−∞	−∞	−∞	−∞	−∞	−∞	−∞	−∞
170	6.84516	7.25608	7.66700	8.07792	8.48884	8.89976	9.31068	9.72160
160	7.13954	7.55046	7.96138	8.37230	8.78322	9.19414	9.60506	0.01598
150	7.30446	7.71538	8.12630	8.53722	8.94814	9.35906	9.76998	0.18090
140	7.41356	7.82448	8.23540	8.64632	9.05724	9.46816	9.87908	0.29000
° 130	7.48974	7.90066	8.31158	8.72250	9.13342	9.54434	9.95526	0.36618
60 120	7.54302	7.95394	8.36486	8.77578	9.18670	9.59762	0.00854	0.41946
70 110	7.57848	7.98940	8.40032	8.81124	9.22216	9.63308	0.04400	0.45492
80 100	7.59884	8.00976	8.42068	8.83160	9.24252	9.65344	0.06436	0.47528
90 90	7.60549	8.01641	8.42733	8.83825	9.24917	9.66009	0.07101	0.48193

Values of the vertical velocity, $w = 2\,A \sin az$.

az = 180°	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
170	0.0007	0.0018	0.0046	0.0120	0.0308	0.0794	0.2045	0.5267
160	0.0014	0.0036	0.0091	0.0236	0.0607	0.1564	0.4028	1.0375
150	0.0020	0.0052	0.0134	0.0345	0.0887	0.2286	0.5888	1.5167
140	0.0026	0.0067	0.0172	0.0443	0.1141	0.2939	0.7570	1.9499
° 130	0.0031	0.0080	0.0205	0.0528	0.1360	0.3502	0.9021	2.3237
60 120	0.0035	0.0090	0.0232	0.0597	0.1537	0.3959	1.0199	2.6270
70 110	0.0038	0.0098	0.0251	0.0648	0.1668	0.4296	1.1066	2.8505
80 100	0.0040	0.0102	0.0263	0.0679	0.1748	0.4502	1.1597	2.9873
90 90	0.0040	0.0104	0.0268	0.0689	0.1775	0.4572	1.1776	3.0334

THE HORIZONTAL ANGLE i AND VERTICAL ANGLE η OF THE CURRENT q IN THE DE WITTE TYPHOON.

It may be observed by comparison with the Cottage City waterspout and the St. Louis tornado how small the angle η, between the stream line and the horizontal plane, has become in the typhoon. It is only a few minutes in arc, except at the inner tubes (7) and (8), and there it is less than 1°. The

helical flow is very flat and the air ascends slowly. In the tornado there is a powerful uplift, but this is lacking in the hurricane, whose destructive winds are nearly horizontal.

TABLE 60.—*The horizontal angle i,*

$$\tan i = \frac{u}{v}.$$

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
°	°	°	°	°	°	°	°	°
az = 180	+90	+90	+90	+90	+90	+90	+90	+90
170	+80	+80	+80	+80	+80	+80	+80	+80
160	+70	+70	+70	+70	+70	+70	+70	+70
150	+60	+60	+60	+60	+60	+60	+60	+60
140	+50	+50	+50	+50	+50	+50	+50	+50
130	+40	+40	+40	+40	+40	+40	+40	+40
120	+30	+30	+30	+30	+30	+30	+30	+30
110	+20	+20	+20	+20	+20	+20	+20	+20
100	+10	+10	+10	+10	+10	+10	+10	+10
90	0	0	0	0	0	0	0	0
80	−10	−10	−10	−10	−10	−10	−10	−10
70	−20	−20	−20	−20	−20	−20	−20	−20
60	−30	−30	−30	−30	−30	−30	−30	−30

TABLE 61.—*The vertical angle η, positive upward,*

$$\tan \eta = \frac{w}{v \sec i}.$$

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
az = 180	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
170	0 8	0 13	0 22	0 35	0 55	1 29	2 22	3 49
160	0 23	0 37	0 59	1 36	2 33	4 6	6 35	10 33
150	0 41	1 5	1 45	2 49	4 31	7 15	11 38	18 40
140	1 00	1 36	2 33	4 6	6 35	10 34	16 57	27 12
° 130	1 17	2 4	3 19	5 20	8 34	13 44	22 3	35 23
60 120	1 33	2 29	3 59	6 25	10 17	16 31	29 46	42 32
70 110	1 45	2 49	4 44	7 15	11 38	18 38	29 57	48 4
80 100	1 53	3 1	4 51	7 46	12 29	20 1	32 8	51 34
90 90	1 55	3 5	4 57	7 57	12 46	20 29	32 53	52 46

TABLE 62.—*The total velocity q, im meters per second.*

$$q = v \sec i \sec \eta.$$

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
°								
az = 180	∞	∞	∞	∞	∞	∞	∞	∞
170	17.29	27.75	44.53	71.47	114.71	184.10	295.46	474.20
160	12.32	19.77	31.73	50.93	81.73	131.18	210.53	337.89
150	10.19	16.35	26.24	42.11	67.58	108.47	174.09	279.41
140	8.99	14.42	23.15	37.15	59.62	95.68	153.57	246.47
° 130	8.23	13.21	21.20	34.03	54.61	87.65	140.68	225.78
60 120	7.74	12.42	19.94	32.00	51.36	82.44	132.31	212.36
70 110	7.43	11.93	19.14	30.72	49.31	79.14	127.02	203.86
80 100	7.26	11.65	18.70	30.01	48.17	77.30	124.07	199.15
90 90	7.20	11.56	18.56	29.78	47.80	76.72	123.13	197.62

Volume of air ascending thru each tube of the DeWitte typhoon.

In the Cottage City waterspout the volume of air ascending thru each tube per second was 16,451.5 cubic meters; in the St. Louis tornado it was 774,500 cubic meters; in the DeWitte typhoon it was 1,588,260,000 cubic meters. The typhoon carried 96,540 times as much as the waterspout and 2,050.5 times as much as the tornado, thru each tube. The total volume of air ascending thru all the seven tubes was 11,117,820,000 cubic meters per second. From these values can be computed other interesting quantities.

TABLE 63.—*Logarithms of the volume of air ascending in each vortex tube per second.*

$$V = \pi\left(\varpi_n^2 - \varpi_{n+1}^2\right) w_m.$$

Altitude.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
°								
az = 170	9.20093	9.20092	9.20092	9.20092	9.20092	9.20092	9.20092	9.20092
150	9.20092	9.20092	9.20092	9.20092	9.20092	9.20092	9.20092	9.20092
90	9.20092	9.20092	9.20092	9.20092	9.20092	9.20091	9.20091	9.20091
60	9.20092	9.20092	9.20092	9.20092	9.20092	9.20092	9.20092	9.20092

EQUATIONS OF MOTION.

If the complete cylindrical equations of motion be written down and the terms substituted as given in the paper on the St. Louis tornado, the partial differentials of the work can be found by multiplying the three equations by $\partial\varpi$, $\varpi\partial\varphi$, and ∂z, respectively. Integrating the equations and adding, also omitting, for the moment, the friction terms, we obtain,

$$(59) \qquad -\frac{P}{\rho} = \tfrac{1}{2}(u^2+v^2+w^2) + \tfrac{1}{2}A^2a^2\varpi^2 + 2A^2\sin^2 az + gz + \text{const.}$$

If now the velocity terms be evaluated they become,

$$(60) \qquad \tfrac{1}{2}(u^2+v^2+w^2) = \tfrac{1}{2}A^2a^2\varpi^2 + 2A^2\sin^2 az,$$

so that

$$(61) \qquad -\frac{P}{\rho} = A^2a^2\varpi^2 + 4A^2\sin^2 az + gz + \text{a constant.}$$

Integrating between two points and restoring the k-terms, the resulting equation for the work done in transporting the mass whose mean density is ρ_m, becomes,

$$(62) \quad -\frac{P}{\rho_m}\Bigg]_n^{n+1} = A^2a^2\varpi^2\Bigg]_n^{n+1} + 4A^2\sin^2 az\Bigg]_n^{n+1} + g(z_{n+1}-z_n) + kq\Bigg]_n^{n+1}.$$

This is the energy required to maintain the circulation under pure vortex conditions, except so far as affected by the coefficient of internal friction. It should be observed that the inertia terms and the expansion or compression terms have each the same value, $\frac{1}{2}A^2a^2\varpi^2 + 2A^2\sin^2 az$. It is customary in meteorology to omit the expansion terms, and write the equation of work,

$$(63) \qquad -\frac{P}{\rho} = \tfrac{1}{2}q^2 + gz + \text{a constant};$$

but in accordance with the above analysis, in the dumb-bell-shaped vortex it is equivalent to

$$(64) \qquad -\frac{P}{\rho} = q^2 + gz + \text{a constant},$$

Similarly, in the funnel-shaped vortex, we have

$$(65) \qquad -\frac{P}{\rho} = C^2(\varpi^2 + 4z^2) + gz + \text{a constant},$$

instead of

$$66) \qquad -\frac{P}{\rho} = \tfrac{1}{2}(u^2+w^2) + \tfrac{1}{2}C^2\varpi^2(1-z^2) + 2C^2z^2 + gz + \text{a constant.}$$

The difference in pressure between successive vortex rings.

We will apply the equation for the work of circulation to the DeWitte typhoon on the sea-level section, $az = 60°$ and $i = -30°$, using equation (62). The term in $4A^2\sin^2 az$ will be found very small on the same plane, as it depends only on A^2, and it will be omitted. The values of $\log A^2a^2\varpi^2$ are taken directly from Table 54.

Take the pressure as given for the typhoon on the sea-level plane and apply these differences in succession.

If we take the oblique course of the air from ring to ring in the nearly horizontal helix whose angle from the tangent is 30° inward, then the length of the path is approximately $(\varpi_n - \varpi_{n+1}) \sec 30°$. We can obtain the coefficient of friction by using simply the u-velocity and the radial distances. Divide the values of ΔB, the difference between the computed and the observed values of B, by the factor 0.0075 to obtain ΔP, and then divide ΔP by $\rho_m u_m (\varpi_n - \varpi_{n+1})$. We thus find the values of k in Table 64.

The mean coefficient of friction is $k = 0.002740$ for the DeWitte typhoon, while for the St. Louis tornado it was $k = 0.2867$, about 100 times as great. It is quite evident that k is a *variable* coefficient depending upon the conditions prevailing in the section of the vortex under discussion. It may differ from one section to another in the same vortex.

TABLE 64.—*Computation of the difference of pressure ΔB between successive rings.*

Term.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\log A^2 a^2 \varpi^2$	1.77762	2.18854	2.59946	3.01038	3.42130	3.83222	4.24314	4.65406
$A^2 a^2 \varpi^2$	59.93	154.36	397.61	1024.2	2638.2	6795.5	17504.	45088.
$A^2a^2\varpi^2_{n+1} - A^2a^2\varpi^2_n$		94.43	243.25	626.6	1614.0	4157.3	10708.	27584
		1.97511	2.38605	2.79699	3.20790	3.61881	4.02971	4.44065
$\log \rho_m$		0.06634	0.06054	0.05468	0.04872	0.04270	0.03658	0.03038
log .0075		7.87506	7.87506	7.87506	7.87506	7.87506	7.87506	7.87506
		9.91651	0.32165	0.72673	1.13168	1.53657	1.94135	2.34609
$B_n - B_{n+1}$		0.82	2.10	5.33	13.54	34.40	87.37	221.65
B_v	760	750	740	730	720	710	700	690
B_e	760	759.2	757.1	751.8	738.8	703.9	616.5	395.8
ΔB (in mm.)	0.0	+9.2	+17.1	+21.8	+18.8	−6.1	−83.5	−294.2
FRICTION COEFFICIENTS.								
$\log k$		7.17129	7.44628	7.55761	7.48756	$\times \frac{1}{\sec 60^\circ} = \cos 60^\circ = 0.500.$		
k (friction)		0.001484	0.002794	0.003611	0.003073			

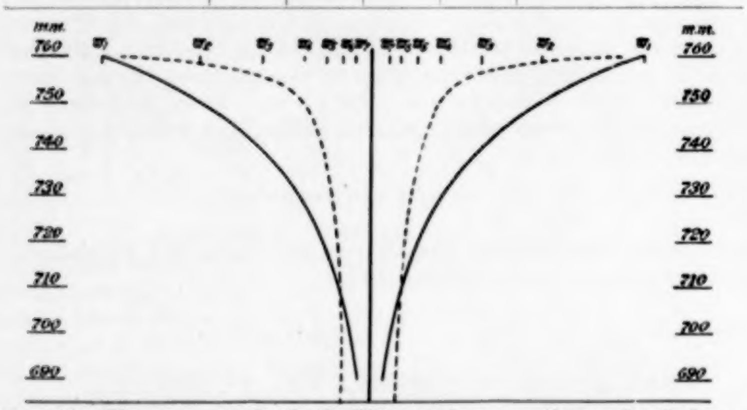

FIG. 16.—The pressures in the DeWitte typhoon, on the sea-level plane. The - - - - - line shows the pressures without friction. The ——— line shows the pressures with friction.

The large differences in the pressures as computed by the pure vortex theory and the pressures found at sea level on the weather maps, Chart IX, figs. 9, 10, 11, of the DeWitte typhoon of course need an explanation. There are two sources of divergence between the theory and the observations. The first is the coefficient of internal friction which has been treated as a simple coefficient of the linear velocity. The second is found in the truncation of the great vortex at sea-level, and the consequent cutting off of the natural source of supply for the upper sections of the tube. If these sections are carrying 158,826,000 cubic meters per second, and this should come from the direction of the sea in the tubes which have been truncated and theoretically end in an asymptotic plane which is 6,000 meters below the sea, it follows that this amount of air must be sucked in at or near the surface of the sea from all sides. It is probable that some of the additional centerward pressure gradient in the outer tubes is required to drive the air into the vortex to supply the demands of the upper sections. It is no simple subject to deal with mechanically or mathematically, and further experience must be acquired before it can be successfully considered in greater detail. It may have been better to reduce the values of k given above in the ratio

$$\frac{k}{\sec 60^\circ} = k \cos 60^\circ = 0.5\, k$$

because the path of the wind is oblique to the radius by the angle $az = 60^\circ$ so that the path length is $\sigma = 2.0\, u$ approximately. The pressure difference $B_n - B_{n+1}$ was accounted for in part by the radial friction instead of the friction along the trajectory, but in the St. Louis tornado the lift in the wind, indicated by the angle η, tended to reduce the friction, and it was supposed that the radial path was more likely to give an idea of the value of the coefficient. In the DeWitte typhoon this consideration does not hold true because η is a very small angle.

The trajectories of the wind.

The discussion has proceeded with no regard, heretofore, to the progressive movement of the entire typhoon, which is always a marked feature of hurricanes. The DeWitte typhoon moved due north between 10 a. m. and 10 p. m. August 2, 1901, about 2 degrees at the rate of 16,000 meters per hour, which is 10 miles per hour or 4.4 meters per second. Between 10 p. m., August 2, and 5 a. m., August 3, it moved toward a little north of west, a distance of 3.7 degrees in 7 hours, which is 32 miles per hour or 14.1 meters per second. The causes which produce this translatory movement of the vortical structure are involved in the complex thermodynamic conditions which pertain to the distribution of masses of different temperatures. The laws for this problem have been summarized in my studies on the thermodynamics of the atmosphere, MONTHLY WEATHER REVIEW, Vol. XXXIV, 1906, but the applications of the formulas will require a more extensive knowledge of the temperatures in the upper strata in the neighborhood of the typhoon, than we now possess.

In forming the equations for the trajectories it may be well to make one remark. All trajectories constructed by taking velocities on a circle whose center moves at a given speed are incompetent to discuss these problems fully, for two reasons. Confining the velocity to the tangential component v, and omitting u, w, the planetary equation becomes, when the motion in the circle is equal to the motion of the center,

$$y \sec^2\theta \frac{d\theta}{ds} = 1 - \sec\theta \qquad \text{(Shaw)}, \tag{67}$$

the case for parabolic motion of the particle. If the center moves slower than the particle in the circle, the path becomes an ellipse; if faster, an hyperbola. It is evident, however, that in the pure vortex motion the primary curve of a stationary structure is a logarithmic curve whose equation may be written,

$$r = e^{a\theta}. \tag{68}$$

In a pure vortex the logarithmic spiral changes the angle of inflow, i, from one section to another, so that a series of spirals must be considered. In the Cloud Report, pages 515–519, the formulas for spirals and polar curves generally have been collected, and Table 87 of that report contains the coordinates (r, θ) for different values of the angle α, which corresponds with az in the formulas for the dumb-bell vortex. The trajectory must be formed by adding the motion of the coordinates of the center to those of the moving particle thru the usual differential equations.

The second difficulty in forming the equation for a trajectory is that, aside from tornadoes and the middle group of rings in a hurricane, the vortex law itself begins to break down in the atmosphere. In the outer and in the inner ring of the most perfect portion of the DeWitte typhoon there are evidences of imperfect vortex action. In the ocean and the land cyclones this disintegration proceeds much farther, owing to the different distribution of the thermal masses having different temperatures. In the case of the DeWitte typhoon the trajectories are not built up out of pure logarithmic spirals, but of polar curves only approximating that simple type. It is, therefore, evident that the subject of trajectories, as well as the resistance by friction and internal vortices, must be considered much more fully than it is proper to do in this series of papers.

THE SUN-SPOTS AS HURRICANES OF THE DUMB-BELL VORTEX TYPE.

The sun-spots occur on the outer surface of the photosphere and extend inward toward the center of the sun. They consist visibly of a nucleus which is practically structureless, and a penumbra which is striated radially with much regularity. The observed movements[5] of the material composing the penumbra are from the outer edge of the disturbed area in the photosphere toward the umbra, and the radial striæ usually terminate in ends which are bent downward toward the interior of the sun. The motion of a particle starting on the outer edge of the penumbra is primarily inward and then rather suddenly downward. This corresponds so closely to the motion in the upper levels of a dumb-bell-shaped vortex where the circulation is downward, that it seems proper to suggest this explanation of the origin and structure of the sun-spots. Referring to MONTHLY WEATHER REVIEW, XXXV, October, 1907, p. 475, fig. 3, the sun-spots would correspond to the layers between the sections $az = 180°$ and $az = 170°$, if the circulation is downward. In this limited region there is practically little rotary velocity v, the vertical velocity w becomes important only when approaching the abrupt curvature which is here assumed to be on the outer edge of the umbra, but in the penumbra the radial velocity u is conspicuous. The sun-spot may be caused by layers of matter inside the sun's photosphere operating to draw material downward, warm layers being superposed upon cold layers at the section which corresponds with the lower plane of the sun-spot vortex. There are reasons for considering the sun-spot belts to be cooler areas than those nearer the poles, so that the general circulation would require downward motion from the surface toward the interior. If these views are correct it will become possible to compute the entire vortex system from a few measurements of the radii ϖ and the radial velocity u in the upper layers of the vortex in the region of the surface of the photosphere. If the penumbra is composed of vapors condensed at a certain temperature, their disappearance as visible cloud forms in the hotter layers, as they fall inward and downward, is readily understood. A large series of thermodynamic problems is clearly suggested by this theory, it may properly become the subject of an important research.

[5]A summary of these papers on the vortices in the atmosphere of the earth was read before the National Academy of Sciences at the meeting in Washington, D. C., April 18, 1907.

The photographs of the sun-spot regions secured by Prof. G. E. Hale at the Mount Wilson Solar Observatory in the summer of 1908 are interesting and suggestive in this connection. The curved lines, perhaps paths of motion, there shown probably belong to other levels in the vortex than that herein described, since curvature in the horizontal plane increases with the distance from the asymptote plane. Measures of the angles and velocities should be made with the dumb-bell-shaped vortex in mind.—*F. H. B.*

NOTES ON WEATHER AND CLIMATE MADE DURING A SUMMER TRIP TO BRAZIL, 1908.

By Prof. R. DeC. WARD, Harvard University. Dated Cambridge, Mass., October 15, 1908.

The teacher of climatology should travel. He should, by personal observation, gain some acquaintance with weather types and with climatic conditions in different parts of the world. If he travels equipped with a few portable meteorological instruments and with his eyes open, he will return from each journey to his class-room better equipped as a teacher and better able to interest and instruct his students. The writer has experienced the truth of these assertions very fully in his own case. He hopes that some of his colleagues may be interested in the following more or less haphazard notes which were jotted down at odd intervals during a recent trip to Brazil. This trip was made as a member of the Shaler Memorial Expedition to South America. The writer accompanied the party without official duties, and largely for reasons of his own health. The start from New York was made on June 20, 1908, and Rio de Janeiro was reached July 8. Six weeks were spent in Brazil. On the return voyage the steamer left Rio on August 19, and reached New York September 6. Short stops were made at Bahia and Barbados.

Instrumental equipment.

The instrumental equipment was simple and portable. The following list of instruments is given in the hope that others may find it useful: 2 sling psychrometers; small-size Richard barograph[1]; portable maximum and minimum thermometers[2]; 3-inch rain-gage[2]; nephoscope[3]; Dines's patent portable pressure anemometer[4]; Rotch's instrument for obtaining the true direction and velocity of the wind at sea[5]; a pocket compass. In addition, charts of the North and South Atlantic and a United States Hydrographic Office Pilot Chart of the North Atlantic Ocean for June, 1908, were taken. This equipment proved satisfactory, and as complete as the conditions of ordinary travel warrant.

THE ATLANTIC VOYAGE.

No study of pilot charts or of text-books can give the clear understanding and appreciation of the great wind systems of the world which the traveler who takes an ocean voyage can secure by keeping his eyes open. In June, the month in which the writer started from New York, summer conditions are well established over the North Atlantic. The Pilot Chart shows that the dominant high-pressure area is somewhat to the southwest of the Azores, and covers the central and southern portions of the ocean. From this center, as is well known, the winds blow out spirally.

The prevailing westerlies of the North Atlantic.

To the north of the anticyclone their direction is generally from the southwest, and we have the *prevailing* or *stormy westerlies.* These are often interrupted by cyclones, which cause changes of wind direction to southeast or south with foul weather and rain, followed by a shift to the southwest and west or northwest with clearing weather and higher wind velocities. In these westerlies the pressure changes from day to day are irregular, and often reach 0.50 inch or more. The winds, while generally strong, are variable both in direction and velocity. During the colder months the storms increase in number and are more violent; the shifts of wind are more frequent; the periods of rainy and cloudy weather come oftener and the winds have higher velocities. Because the "Atlantic Ferry" runs thru the latitudes of the stormy westerlies, the passage is apt to take a steamer thru one or more storms, especially in the colder months. There are fewer changes in weather and in pressure on the eastward voyage than on the westward. This is because the storms themselves move eastward, and the

[1]A most interesting traveling companion on an ocean voyage. The barograph was hung from the ceiling of the stateroom by a spiral spring, and was prevented from swinging too violently by means of a string fastened to the side of the room. This same instrument accompanied the writer in 1897-98 on a voyage around South America, and gave a continuous and most interesting record from New York back to New York again.

[2]Not used because of difficulty of proper exposure.

[3]Modified Fornioni pattern (see Cleveland Abbe: Report of Chief Signal Officer for 1887, Part 2, p. 330-331, Pl. XXXII, fig. 86), specially constructed for the writer by Mr. S. P. Fergusson, of Blue Hill Observatory. This nephoscope measures 5½ inches in diameter, and has an adjustable eye-piece in two sections. When used at sea, if the vessel is rolling or pitching, some difficulty is experienced in making an observation, but in smooth seas, such as those met with on the voyage to Brazil, this trouble is reduced to a minimum. For a description of a marine nephoscope mounted on gymbals, see Cleveland Abbe: The Marine Nephoscope. U. S. Weather Bureau Bulletin No. 11, Pt. I, sec. III, p. 161-167, and Pl. VI.

[4]An excellent instrument for use on land. On a moving steamer it is impossible to obtain the true wind velocity directly from anemometer readings. The instrument is made by Casella of London.

[5]A very useful and interesting instrument, described by Prof. A. L. Rotch in the Quart. Journ. Roy. Met. Soc., Vol. XXX, p. 313. The angle between wind direction and the ship's course on these particular voyages to and from Brazil was usually so small that this instrument could not be satisfactorily employed during most of the time.

steamer travels along with them. On the westward voyage the ship moves toward the approaching storms and in a given number of days is therefore likely to pass thru more of such disturbances than when she travels eastward. On the westward voyage observer and storm approach one another at a rate equal to that of the westward velocity of movement of the steamer *plus* the eastward velocity of the storm. On the eastward voyage the rate of approach of observer and storm is equal to the difference of these velocities. The weather of the northern North Atlantic is characteristically boisterous, and the sea is apt to be rough.

The voyage across the latitudes to the south of the dominant anticyclone takes the traveler thru very different conditions. Here the winds blow from a prevailing northeast direction (the northeast trades) toward the equator. The trade winds blow over a region where the distribution of pressure is very uniform, and where the decrease of pressure with decrease of latitude is slight. Hence, these winds have a moderate but very constant velocity, and are remarkably steady in direction. The Pilot Chart shows clearly enough that the region of gales is in the northern part of the ocean, in the belt of prevailing westerly winds, while the trade wind latitudes are not subject to gales.

The first two or three days after leaving New York the weather may be unpleasant, especially in winter, but as the steamer takes a course very nearly southeast (passing to the west of Bermuda) until she is off Cape San Roque, she soon runs out of any temporary stormy conditions near the coast, and a day or two of fine weather, with generally light and variable winds, is encountered. In summer, calm sea and fine weather are likely from the start, with southwest winds for the first four or five days. These southwest winds are a part of the general spiral outflow from the permanent anticyclone near the Azores. They are clearly shown on the *Challenger* isobaric and wind chart for July, over the western portion of the North Atlantic. The Pilot Chart also shows them well in the "squares" around Bermuda. The steamer on which the writer was a passenger carried these southwesterly winds and fine weather for four days and a half after sailing from New York. The clouds were mostly of the cumulus type (cumulus, alto-cumulus, strato-cumulus), sometimes reaching cumulo-nimbus development in the afternoon and giving short, squally showers, but disappearing about sunset. The clouds came from about southwest thruout this time, except the cirrus which came from more nearly west. The lofty tops of the cumulo-nimbus were often observed to bend forward and topple over, dissolving as they descended below the level of previous condensation. This breaking off of the cumulo-nimbus tops frequently gave the remaining portion of the cloud a strato-cumulus appearance.

The Horse Latitudes of the North Atlantic.

The barograph curve showed a very steady rise after leaving New York, reaching its highest reading (30.25 inches) southeast of Bermuda, where the axis of the tropical high-pressure belt ("Horse Latitudes") was crost June 23–24. The noon position on June 24 was latitude 26° 00′ north, longitude 60° 32′ west. The southwesterly winds noted above became very light and even failed altogether in this part of the voyage, and typical Horse Latitude calms were experienced. It was thus easy to see why this particular portion of the ocean is avoided, when possible, by sailing ships. The old stories about vessels being becalmed in the Sargasso Sea and drifting around amid great masses of seaweed until they rotted away, were associated with these latitudes of the tropical calms. The diurnal variation of the barometer first became noticeable on June 22 and grew more marked with decreasing latitude, being a regular feature of each day's barograph curve during the remainder of the voyage and most marked near the equator. The temperature rose gradually as the ship went farther south, but remained under 80° during these first four days. The relative humidity averaged about 80 per cent. (D. B. 77.5°, W. B. 73.0°.)

The northeast trades.

Late on the afternoon of June 23 (noon position lat. 29° 46′ north, long. 63° 44′ west), during a calm, some fracto-cumulus clouds were observed coming from south 25° east, showing the presence of a wind from that direction at about a mile above sea-level. In half an hour the northeast trade began to blow, at first from about southeast. On the following day the wind was fresh from east-southeast. It was noted that this wind began about 3° or 4° north of the northern limit of the northeast trade, as shown on the June Pilot Chart, but when the steamer was already in a "square" where east and southeast winds are shown to be prevalent. On June 24 (noon lat. 26° 00′ north) the charted "northern limit of the northeast trades" was reached. For six days the weather conditions were ideal. Fresh easterly winds blow day and night with just enough white caps to keep the sea from being "dead;" beautiful trade cumulus clouds, like our own summer clouds at home, but usually more delicate and much more slender, shine brilliantly in the tropical sun by day, growing larger in the later afternoon hours, when as cumulo-nimbus they often give brief showers, and fading away after glorious sunsets; temperatures never vary more than 2° or 3° above or below 80°, but one is perfectly comfortable owing to the fresh breeze and fairly low relative humidity (about 75 per cent). Sailing under such conditions is certain to make even the most blasé traveler enthusiastic over the sea.

Short rain squalls, lasting five or ten minutes, were by no means infrequent in the northeast trades. These squalls were accompanied by a considerable freshening of the wind. In one case a slight, sudden increase in pressure was noted on the barograph curve, and a fall of temperature of 4° was observed at another time. Lightning was noted only once. Most of the showers came in the late afternoon, evening, and night. Fairly well-developed cumulo-nimbus clouds were not uncommon even in the early morning hours. This fact, together with the occurrence of showers at night, suggests that radiation aloft, from the clouds themselves, is an important cause of atmospheric instability in these latitudes.

The pressure changes from day to day are very small in the trades. Storms are rare, and are limited to certain seasons. The voyager over these seas may therefore be sure[6] of a succession of beautiful days, so much alike that he soon acquires the habit of the Tropics and stops talking about the weather. When day after day brings the same conditions, with which everyone soon becomes familiar, to talk about the weather is as aimless as to greet everyone with the exclamation, "The sun rose this morning!" In extra-tropical latitudes, where weather changes are frequent, the weather is naturally and will always remain a stock subject for conversation.

Several observations of flying-fish showed that these fish can remain above water a surprisingly long time. While the average duration of their flight was between six and eight seconds, it extended to eighteen seconds in one case. The sea during these observations was smooth. Over rough water, the duration of flight may be longer.

The heat equator.

On June 25 the sun was vertically overhead at noon. It was interesting to note that the maximum temperature recorded on the voyage (81°) was not reached until June 26, i. e., farther south. This suggests the fact that the heat equator, in its migrations, lags behind the sun. As the steamer proceeded farther southward, the temperatures began to average some-

[6] Except in the hurricane season and hurricane belt.

what lower and had fallen to 75° by the time Rio de Janeiro was reached. It was clearly seen that the temperatures within 5° or 10° north of the equator were somewhat higher than those the same distance south of "the line."

The doldrums.

Thruout the six days during which the steamer was traversing the northeast trades, the wind was persistently from the east. The Pilot Chart for June shows that in these latitudes the prevailing wind is northeast, but that east winds are also frequent. In the summer of the Northern Hemisphere the northeast trades end between latitudes 5° and 10° north. The ship ran out of the northeast trades and into the doldrums at almost exactly the latitude indicated on the chart. The doldrum belt, with its characteristic heavy cumulo-nimbus clouds, its frequent heavy showers and squalls, its high temperature and damp air (relative humidity 80 per cent or over), was crost in about twenty-four hours. This indicates a width of 300 miles, more or less. The wind continued from the east during much of this time, but was often interrupted by calms.

Cloud movements in the doldrums.—Much interest attaches to the directions of cloud movement in the doldrum belt, because of their bearing on the theory of the general circulation of the atmosphere. On June 29, at 2:30 p. m. (noon position, lat. 8° 46′ north, long. 44° 47′ west) cirrus was observed coming from the east, cirro-cumulus from east 20° south, and fracto-cumulus from the southeast, the wind being from the east. At 3 p. m. cirrus and cirro-cumulus were observed moving from the east. The east-west drift near the equator is here clearly indicated. These observations were taken near the southern limit of the northeast trade. On June 30 (lat. 5° 26′ north, long. 41° 21′ west) cirrus was noted coming from east 10° south, the vessel being then in the doldrum calms. The transition from doldrums to southeast trade was gradual, at about latitude 4° north. The lower clouds came from the southeast before the wind began to blow from that direction. In latitude 2° 39′ north, longitude 37° 39′ west, alto-cumulus was observed coming from southeast by east, and also from east 10° south.

The southeast trades.

For six days more, nearly to Rio de Janeiro, the delightful tradewind conditions already described were again experienced; six days more of ideal temperature, wind, sea, and sky, where simply to sit on deck is unalloyed satisfaction, and where, with the fresh, balmy trades blowing into one's open door and port-holes, sleep comes readily to those who, when ashore, dread the wakeful hours of the night. No high clouds were noted in the southeast trades. On July 3 the "green ray" was seen at sunset. The sun went down behind a heavy mass of trade cumulus, but the base of these clouds was about 10° above the horizon, so that the whole disk of the sun was visible as it set. After passing Cape San Roque the steamer's course took her not far offshore and it was noted that showers became more frequent. This is a characteristic phenomenon on windward coasts in the trades. Pernambuco, it will be remembered, has winter rains. It was also observed that near land the trades were less steady in direction. The development of heavy cumulus clouds over the land was clearly shown.

These same conditions were noted in these waters on the return voyage. After passing the northern tropical high-pressure belt, the barograph curve showed a general fall until the doldrums were reached, when a gradual rise began again as the steamer proceeded southward. The diurnal variation continued well marked, but less regular as higher latitudes were reached. The last day before reaching Rio de Janeiro the wind was northwest off the land.

THE STOP AT RIO DE JANEIRO.

Three weeks were spent in Rio de Janeiro (July 8–22, August 13–20). This period, altho short, gave a fair opportunity to study the winter weather types in the Brazilian capital. The winter climate of Rio is justly praised by the inhabitants. During the spells of fine weather, which are the dominant type, the early mornings are apt to be foggy, especially over the harbor and the lower portions of the city. This fog soon "burns off" and rises, breaking up into fracto-stratus clouds which later disappear. The days are fine, usually with a considerable development of cumulus or even cumulo-nimbus clouds, and the evenings are again clear. The temperatures as taken by the writer at his hotel averaged about 68° between 7 and 8 a. m., and 75° to 78° in the noon hours. During the heat of the day people wisely seek the shady side of the street and use sun-umbrellas. The mean temperature of Rio in July is 69.4°. The mornings and evenings are sufficiently cool to be delightful. Light overcoats are often comfortable when riding on the electric cars at night. The sight of the motormen enveloped in thick ulsters, running their cars thru streets lined with palm trees and illuminated by electric lights gives one a very singular impression of incongruity. In most of the Rio houses the windows are never shut. In fact, the "windows" usually have glass in the upper half only. The lower half is a louvered panel thru which the air is free to circulate. The prevailing winds are north-northwest by night and south-southeast by day thruout the year; but the night wind lasts until late in the morning. In the interval between these two winds calms prevail. Nephoscope observations during these intervals showed an almost perfect stagnation of the atmosphere. In general, the clouds at Rio were found to move from about west-southwest, a direction which accords quite well with theory. On one occasion, during the clearing off of a storm, some alto-cumulus were observed coming from west 10° north.

Winter is not the rainiest season in Rio, but occasional short spells of cooler, cloudy, and rainy weather interrupt the succession of fine days. The rains are generally light and do not last more than a day. A fairly heavy rain on July 16–18, which caused some damage in parts of Rio, gave an opportunity to see what weather map conditions[7] preceded and accompanied the storm. The pressure at Rio rose from July 14 to 18, and the writer's barograph showed a higher pressure at 10 a. m. on July 18 than at any other time during the period July 8–22. The diurnal variation remained fairly well marked during all these days. On July 15 Santos, 180 miles south of Rio, had rain in the morning, and Paranagua, about 150 miles farther south, reported fresh southwest winds on the preceding afternoon with rain on the morning of the 15th. At 9 a. m. July 16 the wind at Rio was northwest; Santos reported rain with a south wind; Paranagua had rain and a southeast wind. Rain began at Rio on the afternoon of the 16th, after a rapid clouding, and continued fairly heavy at times until noon of the 18th. These rains came in connection with a weak cyclonic area. The cyclone moved up from the southwest, in a general easterly direction, and then apparently past off to sea to the north of Rio.

The climate of Rio is unquestionably favorable to the development of the *anopheles* mosquito, and for long years yellow fever was prevalent in the city. But recently, thru the strenuous efforts of the sanitary authorities, the disease has been practically driven out. At the little English Hospital up on the hills above the city, the English nurses talk about "the old days of the fever." Petropolis, that charming little town 2,700 feet up among the Organ Mountains, need no longer rest its reputation upon the fact that to spend one's evenings and nights there insures safety from yellow fever. The cool nights, the attractive villas and gardens, and the surrounding mountains are sufficient to insure the popularity of Petropolis in the future.

[7] See also Monthly Weather Review, XXXVI, September, 1908, Chart IX.

THE CAMPOS OF SAO PAULO AND PARANA.

A hurried trip across the campos of southeastern Brazil (July 29–August 12), made partly by rail and partly in a rude form of buckboard drawn by four mules and known in Brazil as a "trolley," gave an opportunity to see something of a region which is destined to be of great economic importance in the not distant future. This journey led from Rio de Janeiro in a general southwesterly direction across the State of São Paulo and about half way across the State of Paraná, which adjoins São Paulo on the south. This portion of the country is seldom visited by tourists. Owing to the exigencies of travel, the amount of baggage had to be reduced to a minimum, and for most of the time the sling psychrometer was the only instrument at hand. Our route followed the Sorocabana Railway from São Paulo to its terminus at Buri. We crost the campos by "trolley" via Faxina to Itararé, took the São Paulo and Rio Grande Railway from Itararé to Punta Grossa, and then the Paraná Railway to Curityba. See the map, fig. 1.

FIG. 1.—Sketch map of the State of São Paulo, Brazil.

Campos, not dense tropical forests, are characteristic of most of Brazil. Fully three-quarters of the country are occupied by these wonderful rolling plains, here stretching as far as the eye can reach without other vegetation than tufts of coarse "goat's beard" grass, perhaps interspersed now and then with large brakes or stemless palms; here sparsely covered with scattering scrubby, gnarled trees, giving an appearance much like that of an old apple orchard whose trees are dead or dying; there again covered with a dense growth of trees and shrubs, all entangled with vines and creepers, and covered with long gray moss ("old man's beard"). Monotonous these Brazillian campos certainly are. They are vast. They are grim. But the monotony becomes variety to the observing traveler who catches the spirit of the place; who notes the change from open country to woodland, and from woodland to the sparsely-treed sections. There is infinite variety in the constant change of color; in the succession of forest and field; in the shifting cloud-shadows and bright sunlight. Very striking are the sudden transitions from open campo to dense forest: as sudden as if due to human agency, but in reality the work of nature or of fire. Fire has had much to do in determining present conditions on the compos. As one travels across these stretches by train or on horseback, the blackened fields and bare tree-trunks, furnish abundant evidence of the work of fire. In the dry season, scarcely an hour of the day or night passes without revealing the smoke or flame of a fire in progress—a fire which may have been burning for days.

The region crost by the writer is to-day very sparsely settled. A few small towns, at great distances apart; occasional scattering fazendas (ranches), or small huts built of adobe or wood, separated often by tens or twenties of miles—that is the present condition of occupation by man. Herds of cattle, horses, mules, and hogs are occasionally seen scattered over the immense streatches of open fields. Here and there, around the towns or where some settler has placed his lonely cabin, a little rude cultivation is attempted; some beans, manioc, and corn are raised, and where conditions are favorable, bananas, oranges, sugar cane, or rice may be seen. On the whole, the campos of this portion of southeastern Brazil are to-day examples of colossal waste—waste of sunshine, waste of rainfall, waste of soil. For leagues and leagues there are no houses, no cultivation, no human beings. In the State of Paraná, where there is more rainfall, one sees more cattle and horses; and there are more forests. Hence, lumbering and various industries which depend upon lumber, attract the attention of the traveler. There is no more interesting question in Brazil today, from the point of view of the development of the country, than that which concerns the future of these campos. What shall be done with them? Can they be made to produce good

pasturage? Can they be used for cereals? Are they to be a farming country?

The climate of the Brazilian campos.

The climate of these interior campos of São Paula and Paraná (average elevation about 2,500–3,000 feet above sea-level) is continental, with the modifications due to altitude. It is cooler and less humid and more desirable in every way for European immigrants than the seacoast, or the campos of the more northern states of Brazil nearer the equator. It is therefore natural that Europeans have settled so largely in the southern states, and it is inevitable that these states will become the most important, industrially and economically, in the country. The climatic conditions will bring about that result.

The campos of southeastern Brazil unquestionably have a winter climate which deserves the praise it has generally received from those who know it. Clear or fair days, with a strong diurnal range of temperature, were the dominant weather type in the latter part of July and early in August. The fresh, crisp, cool air and cloudless skies of early morning[8] are succeeded by a warm noon and early afternoon, with fresh southeast wind showing a distinct diurnal variation in velocity, and with a considerable development of cumulus clouds. The direction of the prevailing wind is clearly shown by the unsymmetrical growth of trees in exposed locations. Toward sunset the temperature begins to fall rapidly; the clouds dissolve, and clear, or perhaps foggy, nights follow with light wind or a calm. During winter nights, even in the northern part of the State of São Paulo, frost is by no means uncommon and the coffee plants are liable to injury on that account. The writer saw banana trees frost-bitten in a valley bottom in São Paulo at an elevation of about 2,000 feet above sea level. Farther south, owing to the increasing danger from frost, the coffee is planted at greater elevations on the hillsides. In Paraná, the minimum winter temperatures are a few degrees below freezing, and occur on nights following rains and southwest winds. During fine weather in winter the conditions are ideal for health and pleasure.

The rainfall on these campos is at a maximum in summer, but rains are evidently not wholly absent in the so-called "dry season." During the two weeks and a half spent by the writer on these campos rain fell on three occasions. On two of these the precipitation was cyclonic. The first storm began late one afternoon, with thunder and lightning, and continued about twelve hours as a heavy general rain with northerly winds, clearing off thru southeast and south to southwest, with somewhat lower temperature. The second storm was experienced in Paraná, farther south. It began at noon on August 1 as a very light, drizzling rain, following a clear sky on July 31. The wind was southeast, light, all day, and the temperature between 50° and 60°. A thunder-storm preceded the general rain, as in the case just referred to above, and the sky remained overcast about twenty-four hours, with a fine mist during most of that time. This storm cleared off with a west-northwest wind.[9] As soon as the cloud sheet broke up, about noon, the temperature rose about five degrees, reaching 55.5° at 2.30 p. m. The general rain clouds were soon succeeded by cumulus clouds.

The third rain was from cumulo-nimbus clouds. This thunder-storm was encountered in the open campo south of Buri about 5 p. m., July 25. It came up from the southwest, a magnificent anvil-shaped mass, with a long gray rolling squall-cloud below, advancing as an arched squall across the campos. A rough estimate gave the storm a width of about 30 miles. The lightning was vivid and constant. Only the northern edge of the storm reached the writer. A heavy fall of hail lasted about ten minutes, accompanied by a torrential downpour of rain. The average hailstones were about the size of small marbles; a few were larger. The hailstones collected in hollows to such a depth in some places that they could have been shoveled up. For an hour after the storm the wheels of the vehicle crunched thru hailstones at different points on the road. The bombardment was so heavy during the storm that the mules refused to face the wind, the leaders deliberately turning their heads to leeward in spite of all the driver could do. The rain washt the road badly on all slopes, gullies 2 or 3 feet deep being worn out in a few minutes. In the deeper hollows the water and mud and hail collected to a depth sufficient to make the crossing difficult. Unfortunately it was too dark to make any minute examination of the hail. The wind blew with considerable velocity toward the advancing storm for about a minute before the rain began, and the storm was followed by a calm, and close, muggy air.

At Jaguariahyva, the present northern terminus of the São Paulo and Rio Grande Railway, the meteorological record kept at the railroad offices showed the following conditions of rainfall: In February, rain on one whole day, two three-quarter days, two one-half days, and five one-quarter days; in April, rain on one whole day, and on three three-quarter days; in June, rain on one one-half day, and one whole day; in July, rain on three whole days in succession, on one one-half day, and one three-quarter day, the latter in succession. The record at this station covers rainfall only, recorded in the manner here given. Curityba (lat. 25° 25′ south, long. 49° 15′ west, altitude 908 meters), the capital of the State of Paraná, well illustrates the climatic conditions of the southern part of the campos where the writer crost them. At this place the maximum temperatures of early August are not far from 70°, while the minima fall to 45° or 50°, and sometimes lower. The prevailing winds were northeast and southeast; the relative humidity about 80 per cent. No rain fell during the writer's stay in Curityba, but the winter months are by no means rainless, July and August having mean rainfalls of 2.48 inches and 3.81 inches, respectively. The days were fine, with a predominance of cumulus clouds; and the diurnal temperature variation was very marked, with cool mornings and nights and warm afternoons. Nocturnal radiation fogs are evidently common in winter.

The fertility of the campos.

It is clear that the climatic conditions of the campos of southern Brazil are on the whole very favorable for the future utilization of this immense area. The soil is also, in the main, very good. Of course, conditions of climate and of soil vary in different parts of these campos. In some places the rainfall of the dry season is probably insufficient for agriculture without irrigation; in other places the soil is doubtless less fertile. But in the large, the Brazilian southern campos are better off than much of our own western country which now yields good returns in cattle and crops. The replacement of the "goat's beard" tufted grass by the native "catingueiro" provides excellent pasturage for cattle and horses. When the former grass is burned off, the soil plowed or dug under, and the "catingueiro" planted, the latter has been able to maintain itself, especially where the rainfall is abundant. In some places European grasses have been successfully sown, and it is almost certain that with proper care alfalfa or some other supplementary forage crop can be grown where necessary in order to provide fodder during the dry season. As to cereals, it is too early to venture any reasonable forecast. Vegetables have succeeded well where proper care has been given them, Some light is thrown on the latent possibilities of the country by the success which has been attained at the

[8] Observations made at odd times by the writer, but usually taken between 7 and 8 a. m. The readings in the early afternoon (12–2) gave 75°–80°.

[9] This was probably a local wind direction.

agricultural experiment station at Piracicaba in the State of São Paulo. Prof. J. William Hart, one of the corps of instructors at the station, reported to the writer that at this *Fazenda Modele* rather remarkable success has been attained in the cultivation of corn, barley, rice, cotton, alfalfa, and other crops. Again, at a ranch owned by a Frenchman, not far from Ponta Grossa, similar success with many different kinds of crops is reported. The best utilization of the campos is simply a question of time, of hard work, and of continued experimentation with different kinds of crops. Experiment stations should be established at several different points on the campos, and at each station every effort should be made to discover what kinds of crops will succeed best. At present the people are acting largely without intelligence, even when they make an effort to raise vegetables or other crops. They are not adapting their crops or their labor, which is very haphazard, to the climatic conditions. Cereals can doubtless be found which will succeed, possibly without, possibly better with, irrigation, Certainly in the more southern parts of the campos, e. g., over much of Paraná, there is abundant water for irrigating an immense number of farms.

No one who crosses these campos of southern Brazil to-day can for a moment doubt that the country has a splendid future. It may be almost wholly a cattle country; it may be most valuable for sheep raising; it may perhaps be best utilized for corn, or wheat. To the writer it seems likely that the campos of the states of São Paulo and Paraná, and probably also of Santa Catharina and Rio Grande do Sul, might be best utilized as a country of small farms, where horse and cattle raising will be supplemented by crops of alfalfa, sorghum, or corn for the animals, and of vegetables and some cereals for local consumption. Irrigation will doubtless be found desirable, even necessary in places. Climatic obstacles such as hailstorms, drought, sudden heavy rainfalls, and frost, must be reckoned with here as in other parts of the world. The ants must be kept under. Prairie and forest fires must be prevented. Man nowhere finds himself without some such hostile manifestations of nature. The cuts and embankments of the railroads of these campos are prophetic of the future. In imagination the traveler may already see the thru trains between Rio de Janeiro and Montevideo crossing the campos, and may picture to himself this wonderful country, now so striking an example of colossal waste, a settled, peaceful, and prosperous agricultural community.

Supposed climatic changes.

The fact of climatic change has often been regarded as established in cases where certain cereals or fruits formerly successfully raised in a certain locality, later no longer grow there. In Brazil the writer happened upon two cases of this kind which illustrate very clearly the danger of jumping at conclusions in such matters. The first case concerns coffee; the second, cotton. The traveler between Rio de Janeiro and the city of São Paulo may to-day see from the train miles and miles of abandoned coffee plantations on the hills, with the fazendas of fifty years ago falling to ruins in the midst of the old plantations. Whoever looks at these barren hillsides, especially in winter when they are dry and dusty, may easily be tempted to conclude that a change of climate has made coffee growing in this district impossible. Such is not the case. The fact is that coffee has been found to succeed so much better farther south in the State of São Paulo that it no longer pays to keep up most of these old plantations in the State of Rio de Janeiro.

In the second case, that of the cotton, the writer was told that this staple used to be successfully grown along the line of the Sorocabana Railway during our civil war. To-day the three or four cotton factories in and near Sorocabana find the local production of cotton insufficient for their own use, and import the raw material from the north, chiefly from Pernambuco. No change of climate has taken place here. The cultivation of cotton in the United States since 1865 has eliminated the American market. Cotton succeeds better and is produced more cheaply in the north of Brazil; and coffee has been found to yield larger returns than cotton in the State of São Paulo. These three reasons are more than sufficient to account for the abandonment of most of the cotton fields along the line of the Sorocabana Railway.

CLIMATIC CONTRASTS IN BRAZIL.

Two short railroad trips in Brazil furnished striking evidence of climatic contrasts resulting from the presence of mountain barriers. The first, from Curityba, at an altitude of 908 meters, to Paranaguá, at sea level, is made in about five hours. Starting from Curityba, which is situated in a typical campo region, in a cold early morning fog, and crossing the gently rolling, open campos to the east, the train crost the coast range, or Serra do Mar, at an altitude of about 3,000 feet, within two hours. Descending the eastern or seaward slopes by a splendid series of tunnels, viaducts, and embankments, the train reached Paranaguá in about three hours more. The contrast between the campos and the sea-level conditions is remarkable. The seaward slopes of the mountains are densely covered with the most luxuriant vegetation. The trees are overhung with moss, creepers, and parasitic plants of all kinds. The undergrowth is a tangled mass of low shrubs, bamboos, and brakes. Palms, which are absent on the campos, are seen soon after commencing the descent. Then come banana trees, at first singly and scattering; then more and more thickly. On the lower slopes, and especially on the lowlands near sea level, sugar cane, banana groves, guavas, and papaws, furnish striking evidence of the change from the cooler and drier interior upland campos to the warmer and rainier seaward slopes where frost is unknown. The change in temperature and in humidity during the descent is very striking. It was significant that the freight carried was cattle on the campos, while on the seacoast lowlands cars full of bananas were attached to the train.

A second case of marked climatic contrast was obtained on the railroad trip from Santos, the famous coffee port about 200 miles south of Rio de Janeiro, to the city of São Paulo, on the campos. This journey takes the traveler by an inclined plane cable road up to an altitude of a little less than 3,000 feet in a horizontal distance of five miles across the Serra de Mar. The trip, while less picturesque than that from Curityba to Paranaguá, is well worth taking. On the seacoast lowlands there are flourishing plantations of bananas. As the train ascends the densely-wooded seaward slopes of the Serra the bananas are soon left behind, and after the crest is past the well-known features of the campos are again met with. The best time to take this trip is on the 4:30 p. m. train from Santos, for it is then that the change from the hot, steamy atmosphere of Santos to the cool upper slopes and crests of the mountains is most striking. The rainfall on the seaward slopes of the Serra is very heavy. Some years it exceeds 160 inches, and the annual mean at the summit station is 140 inches. The mean temperature at the summit station is 64.4° as against 71.2° at Santos. The engineers of the São Paulo Railway have an incessant struggle to keep their road in repair. The trip from Santos to São Paulo is well worth taking as an illustration of marvelous engineering work in the face of great odds. The whole face of the mountain up which the railroad runs is in places walled up with brick and masonry, and brick or concrete drainage ditches and canals have been built up and down and across the mountain slopes in all directions. One of the engineers of the road made the statement that the ambition of himself and of his colleagues is to know what becomes of every drop of water that falls on the seaward slopes of these mountains.

Certainly this is a very good illustration of the control over railroad construction and operation which results from a heavy rainfall on steep slopes. An old railroad line, the one first constructed and now replaced by the new one at a better grade, is kept open and ready for use in emergencies, in case the new line is washed out. Both the Paranaguá and Santos lines across the coast mountains of Brazil furnish excellent examples of sharp climatic contrasts between warmer, damper, and rainier seacoast lowlands, and cooler, drier uplands within a few miles of the sea but separated by mountains of moderate elevation.

THE RETURN VOYAGE.

The voyage back to New York from Rio de Janeiro (August 19–September 6) brought, in general, a repetition of most of the weather conditions recorded on the outward voyage. The southeast trade with glorious trade weather, trade cumuli, and occasional short rain squalls, was carried up to about latitude 2° north. The temperature rose from 75° to 81.5° as lower latitudes were reached. While at anchor off Bahia, the southeast trade seemed to blow stronger during the warmer hours of the day. The wind here blows away from the city, out over the bay, so that the boats which carry passengers to and from the steamers sail out without difficulty, but must tack or be rowed back to the quay. As the east-southeast and southeast winds weakened light variable winds, calms, and doldrum showers were experienced. The steamer crost the doldrum rain and cloud belt in about twelve hours, but the interval between the well-marked southeast and northeast trades was about twenty-four hours, or 250 to 300 miles. The northeast trade was picked up in about latitude 6° north.

The "green ray" was again observed on August 23. The western sky was clear, except for a few scattering fracto-cumulus clouds above the sun, but the sun itself set in a haze over the land.

After passing Cape San Roque, the ship's course was altered to nearly northwest. The southeast trade thus became a following wind, blowing in the same direction as that in which the vessel was steaming. The relative velocity of the wind felt on board thus became very light and the passengers began to complain of the heat. As a matter of fact, the temperature of the air was exactly the same as when the wind was on our beam; the difference in the "sensible temperature" was due solely to the difference in wind velocity. This is a good illustration of the importance of wind in controlling our feeling of heat or cold, for none of the other factors (temperature, humidity, state of sky, exposure, etc.) which control the "sensible temperature" had changed at all. It was noted that the trade showers, coming from the southeast and therefore moving in the same direction as the steamer, lasted perceptibly longer than when the course of the steamer and the direction of progression of the showers were nearly opposite to one another, as on the outward voyage. Few observations were made with the nephoscope, as practically no clouds except trade cumuli were seen. No cirrus was seen near or on the equator. About 6° north of the equator some cirrus and cirro-cumulus were observed coming from north 10° east and north 20° east.

On August 28, when about 50 to 75 miles offshore, the greenish color of the ocean showed the effect of the fresh water of the Amazon and served to remind the observer of the enormous amount of water which falls as rain over the Amazon Basin. The strong northwest set of the ocean current off the northeastern coast of South America here gave the steamer the largest daily runs logged during the entire voyage, out and back.

While at anchor in Carlisle Bay, Barbados, the effect of the land was noted in the high temperatures observed on board, 84.5° at 4 p. m. being the maximum. No readings as high as this were obtained at sea. While passing within sight of Guadaloupe, Deseada, Antigua, and Barbuda the heavier growth of cumulus clouds over the islands than over the sea was distinctly seen. The temperatures during this time averaged 1° to 2° higher than at a distance from land.

The northern limit of the northeast trade was reached at about latitude 22° north. The easterly wind gradually died out, and a day of very unsettled weather with squalls and thunder-showers followed, and then came the fine weather and light variable winds and calms of the Horse Latitudes. The day before reaching New York there was a northeast wind and cooler weather, followed by falling barometer on September 6, with southeast wind and rain. The change from the steady conditions of the trades had come; the barograph began its familiar irregular curve as it registered the approach and passage of a temperate-latitude cyclone; the general rain, heavy nimbus clouds, and changing wind—all were unmistakable signs that the traveler had again entered the familiar meteorological conditions of home.

The steamer anchored at 6 p. m., Sunday, September 6, off Bedloe's Island in New York Harbor, almost under the shadow of the Statue of Liberty. The closing meteorological scene was a magnificent thunder-storm which past over the city and harbor that night: a fitting ending to a summer spent, as this was, in search of weather.

NOTES FROM THE WEATHER BUREAU LIBRARY.

By C. Fitzhugh Talman, Librarian.

A NEW EDITION OF HANN'S CLIMATOLOGY.[1]

The second edition of Hann's "Handbuch der Klimatologie" was published in 1897, and an English translation of the first volume, dealing with general climatology, was published by R. DeC. Ward in 1903. Volume II and III, which constitute the most extensive climatography of the world that has yet been written, and are the great basis of reference to the literature of the subject down to 1897, have unfortunately not been translated into English.

All meteorologists will welcome with the greatest satisfaction the publication of the third edition of this work, of which the first volume, "General Climatology," has just appeared. The pages are much larger than in the preceding edition; hence Volume I, with a slightly diminished number of pages, contains actually about half again as much reading matter. Nearly every page shows the incorporation of new material, and an entirely new chapter has been added, dealing with the climatic zones of the earth. In the second edition this subject was briefly treated in Volume II.

Even greater interest will attach to the appearance of the remaining volumes, as it is especially the climatographic portions of Hann's work that have fallen behind the present state of knowledge. Many regions that were *terræ incognitæ* in a climatological sense eleven years ago are now dotted over with meteorological stations; and the work of computing normals has everywhere gone ahead rapidly. Hence, the two volumes on special climatology, tho indispensable in the absence of any later authority, are in urgent need of revision.

METEOROLOGY IN THE TRANSVAAL.

The annual report of the Meteorological Department of the Transvaal for the year ended June 30, 1907, is at hand, and records a healthy growth in that service, and activity in many interesting lines of work. The number of meteorological stations reporting to the central office at Johannesburg is now 407, an increase of 31 since the last report. On July 1, 1907, the department was transferred from the colonial secretary's office to the lands department.

A daily forecast for the ensuing twenty-four hours is prepared at Johannesburg at 3 p. m. and wired to every postal

[1] Hann, Julius. Handbuch der Klimatologie. 3d ed. I. Band: Allgemeine Klimalehre. Stuttgart: J. Engelhorn. 1908. xiv, 394 p. 8°.

telegraph office in the Transvaal for publication on a notice board. Synoptic maps, however, are not published on account of the expense. Altho a large land area lies to the west of the Transvaal, the advantage of this circumstance for weather forecasting is neutralized by the lack of telegraphic meteorological stations in the region in question. However, a daily telegram is received from Swakopmund, German Southwest Africa, giving the height of the barometer. Besides the forecasts for twenty-four hours, seven-day forecasts are occasionally issued.

An Angström pyrheliometer was added to the equipment of the central observatory during the year. An investigation of the daily amount of chemical radiation from the sun was also undertaken.

Other interesting features of this report are charts showing mean rainfall and mean cloudiness over the Transvaal, based on the records of three years, and a full account of the code used by the observers for weather telegrams.

GERMAN METEOROLOGICAL SOCIETY, HAMBURG, 1908.

The eleventh general meeting of the German Meteorological Society was held at Hamburg September 28–30. The society having reached the twenty-fifth year of its existence, the meeting was regarded as of special interest, and it was attended by a large number of members drawn from all parts of the Empire. In addition, Australia was represented by Messrs. Hunt and Barton, the British Isles by Mr. Harries, France by M. Teisserenc de Bort, Hungary by Hofrat Konkoly, Norway by Vice-Director Aksel Steen, and the United States by Professor Rotch. Professor Hellmann, as president of the society, opened the meeting with a congratulatory speech suitable to the interesting occasion. Admiral Herz, director of the Deutsche Seewarte, was called upon to respond for the official meteorological service; Mr. Harries, as the representative of the Royal Meteorological Society, for the foreign visitors; Professor Dr. Voller for the physical institutions, and Doctor Friedrichsen for the geographical societies. Doctor Hellmann then gave an address on the "Dawn of Meteorology." Subsequently there were five sittings, at which twenty-five papers were discust, the subjects being general meteorology, the meteorology of the upper atmosphere, weather forecasting, and atmospheric electricity. Such an amount of work could only be got thru by steady application from 9 a. m. to 6 p. m. daily. To make up for this the social side of the occasion was not neglected. On Monday night, the 28th, visitors were the guests of the senate of the free town of Hamburg, in the Rathhaus; on Tuesday there was a dinner at the Hamburger Hof; on Wednesday the Hamburg-American Steamship Company took the visitors round the harbor, and on a trip some miles down the Elbe, concluding the excursion with a visit to the liner *König Wilhelm II*. On Thursday the Seewarte and other institutions were thrown open to the visitors, and the afternoon and evening were devoted to the kite and balloon station at Gross-Borstel. The final act of the gathering was a dinner given by Professor and Mrs. Köppen.

It was further announced that MM. Angot and Teisserenc de Bort, Professor Rotch and Doctor Shaw had been elected honorary members of the society.—*Symons's Meteorological Magazine, October, 1908.*

AS TO A DETAILED CLOUD CLASSIFICATION.

Meteorologists are not all of one opinion as to the wisdom of distinguishing and naming subvarieties of the simple types of clouds recognized in the International Classification. Mr. A. W. Clayden, one of the most successful photographers of clouds, recently exhibited some of his pictures at the Franco-British Exposition, and these were labeled in accordance with the elaborate nomenclature proposed in his book "Cloud Studies," published in 1905. They bore such names as cirrus ventosus, cirrus communis, cirrus inconstans, alto-cumulus castellatus, etc.

In the September number of Symons's Meteorological Magazine Mr. L. C. W. Bonacina criticises these names and expresses the opinion that they do not represent sufficiently well-defined types to be of utility. Beyond the simple names of the International System, he thinks that a description, rather than a name, is needed to indicate clearly the character of the clouds in question. A contrary opinion, however, is exprest by M. Albert Bracke, the editor of la Revue Néphologique, in the October number of the latter journal. M. Bracke declares that the subdivisions of the simple types, which have been described by several cloud specialists, are themselves quite typical, and he himself uses the nomenclatures of Clayden and Vincent, both of which he says are easily learned and enable one to express in a word or two the aspect of the sky at the time of observation.

INSTALLATION OF AUTOMATIC RIVER STAGE REGISTER AT HARTFORD, CONN.

By WM. W. NEIFERT, Local Forecaster. Dated: Hartford, Conn., October 10, 1908.

An event memorable in the annals of Hartford was the "Bridge Celebration" of October 6–8, 1908, it being the dedication and the laying of the last stone of the beautiful and durable granite bridge across the Connecticut, which is about one-fifth of a mile wide, at this place. At the very inception of the designs for the bridge, Government officials saw the advantage of being able to secure automatic records of river stages which would be of special interest and value to the people of Connecticut and incidentally to the inhabitants of the 12,000 square miles of territory drained by the Connecticut River. The gaging of such a noble stream gives important data that are of great interest in meteorological work, as well as of much practical value to water-power plants, farmers, shippers, and the lumbering industry. Thru the courtesy of the Bridge Commission provision was made for the proper accomodation of a river stage register within one of the main-channel piers of the bridge indicated by arrow in fig. 1. The Chief of the Weather Bureau, appreciating the durability of the structure, directed that a register be installed, and this work was completed on September 8, 1908, under the supervision of Mr. D. T. Maring, Assistant Chief Instrument Division, of the Central Office. The register is of the latest improved Friez pattern, operating continuously and automatically and is the only one of the kind in present use in this service.

The gage well.—The bridge pier containing the apparatus has a cylindrical shaft, or well, 4 feet in diameter, reaching from a vault or room immediately under the sidewalk of the bridge down to the bed of the river. Access to the interior of the pier is gained from an iron trap-door in the sidewalk of bridge and a step-ladder to the floor of the vault. The well opening around the pipes is covered by a strong wooden platform with detachable manhole. From the river the water is admitted to this well by a 4-inch pipe extending horizontally from the down-stream outer surface of the pier, and consequently the water in the well rises and falls with any rise or fall of the water outside. Within the well is the gage-float guide, consisting of a 10-inch cast-iron pipe which extends vertically from $3\frac{1}{2}$ feet above the surface of the well to 4 feet below the zero of the gage, where it rests on two short lengths of railroad rail placed on the rock foundation. These rails provide a solid base for the heavy pipe and also an intake for the water, tho to produce a better circulation in and around the lower end, a hole about 5 inches wide and 6 inches long was cut out of the float pipe at a point about 3 feet from the bottom. This large pipe is made up of three 12-foot lengths of cast-iron pipe and a top section of wrought-iron pipe 11 feet long. These four sections are well secured together by packing and cement in the bell-joints, and lined up so as to be perfectly

vertical. To this pipe is attached by special iron clamps 44 feet of 1¼-inch galvanized-iron pipe for the counterweight, also plumbed to be vertical and parallel with the float-pipe.

The registering apparatus.—To the top of the gage-float guide-pipe is screwed a cast-iron flange to which the wooden support of the instrument is fastened in such manner that the sprocket-wheel of the register comes directly over this pipe, as illustrated in fig. 2.

The instrument, with cover case open, is clearly shown in fig. 2. It consists of a metal base on which is mounted the

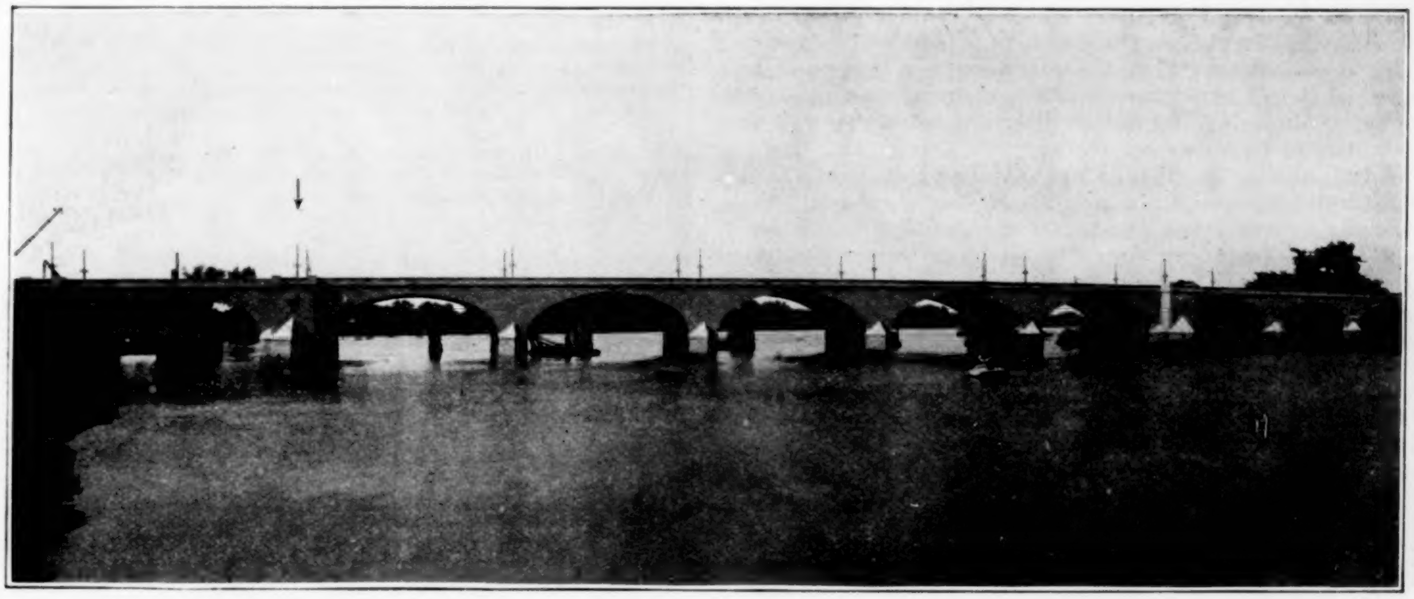

Fig. 1.—Connecticut River Bridge, Hartford, Conn.[1] (Looking north. Main-channel pier, No. 1, indicated by arrow—river-gage in vault at ×.)

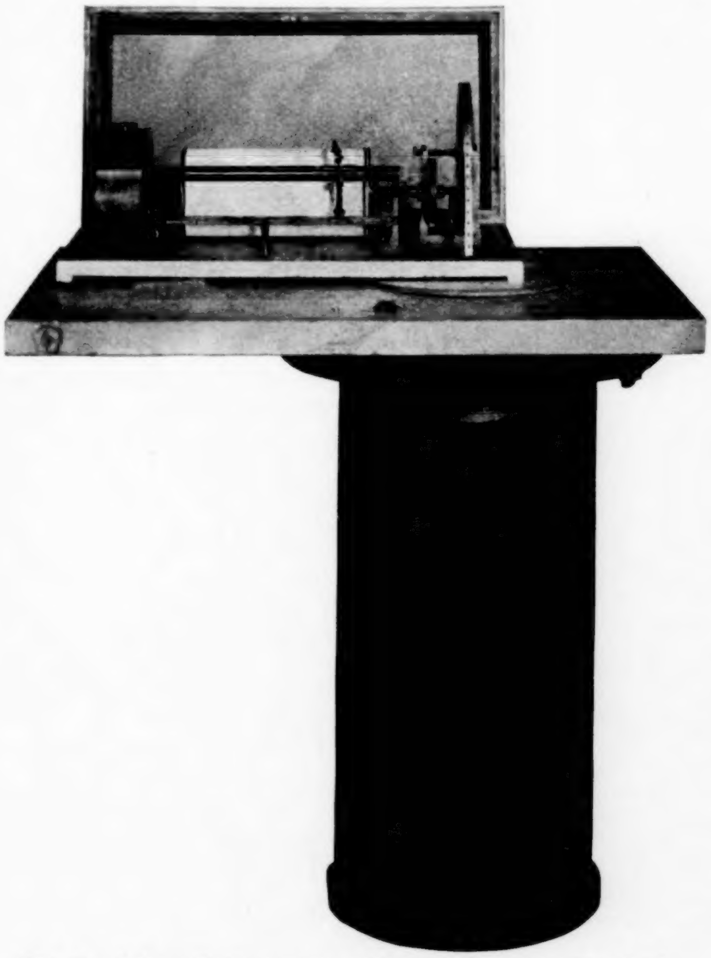

Fig. 2.—Automatic river-gage register, with glass cover raised.

usual eight-day power clock for propelling a recording-pen carriage by means of a feed-screw. With the clock mechanism is a revolvable record-drum 8 inches long and 12 inches in circumference, which carries the weekly record-sheet. The delicately mounted sprocket-wheel on the right has motion communicated to it by a very light and flexible phosphor-bronze perforated tape or band passing over accurately spaced pins on the circumference of the wheel. The tape is attached at one end to a 7-inch copper float and at the other to a small counterweight running up and down in the smaller pipe. As the water in the shaft rises it carries the float with it, causing the tape to move. This movement of the tape turns the sprocket-wheel, which communicates its motion to the record-drum thru suitable gears having a recording ratio of 1 to 20. One revolution of the drum (or 12 inches) thus equals 20 feet rise or fall of water. The engraved part of the sheet is also 8 by 12 inches, ruled and spaced to indicate hours of time, and feet and fifths of water stage. The perforations of the tape provide for a range from 2 feet below the gage zero to 39 feet above.

As installed the register is fitted with a glass case having lock and key. Over all is placed a rubber sheet to keep out dirt and dampness, and on the outside is attached a notice warning the public not to interfere with the apparatus.

Remarks.—Experience with this installation suggests a word of caution in future installations of this kind. Acting under instructions, the contractors put in only a 4-inch intake pipe between the bottom of the well and the channel outside of

[1] This is the largest stone arch bridge in the world. Total length 1,120 feet, nine spans. Maximum clear height to intrados of arch above low water, 45 feet. Width outside spandrel walls, 82 feet. Clear roadway, 80 feet, viz: Two 10-foot sidewalks and 60 feet between curbs for two carriageways and two street-car tracks. Foundations carried to 50 feet below low water. Weight of largest finished stone used in the construction, about 40 tons. Total amount of masonry in bridge proper, about 100,000 cubic yards. Cement used in construction, about 125,000 barrels. Cost of bridge $1,600,000, and with approaches complete nearly $3,000,000. Chief Engineer, Edwin H. Graves; Deputy Chief Engineer, John T. Henderson; Assistant Engineer, Edward W. Bush.

the pier. This was laid in 1906, and it had become completely filled with sand and silt at the time of installing the register in 1908. This pipe should have been at least 8 inches in diameter, and there should have been another pipe outlet to the channel arranged so there would always be a slight movement of water thru the bottom of the well. Thus the inlets would tend to keep themselves clear. A 2-inch pipe is now in place several feet above the 4-inch pipe, and will, of course, do this to some extent when the water is above that point, but it is feared it will hardly prove sufficient for the purpose, and a special annual cleaning out of the bottom of the well and the lower inlet-pipe may be required.

The 10-inch float-guide pipe was installed in sections as the work of building up the pier progressed, but no special efforts were made to avoid the accidental deposit therein of wood, crusht stone, cement, and filth by careless workmen. Both well and pipe should be kept closed during the building operations of all bridge piers intended for the use of registering river gages. Where possible, more light and ventilation should also be provided for the vault room containing the registering apparatus.

The records thus far obtained at Hartford have been checked daily by eye observations of the ordinary river-gage, and have been found exceedingly accurate. They will doubtless prove of great value in the river work of this section.

THE METEOROLOGY OF MARS.

By Prof. Simon Newcomb. [Reprinted from Harper's Weekly for 25th of July 1908.]

The study of the atmospheres of each of the other planets of our solar system is likely to add something to our knowledge of our own atmosphere, and we commend to our readers the following extract from a longer article by our distinguished colleague in astronomy.—*C. A.*

There are two points concerning Mars on which we can speak with a fair approach to certainty, and which will be most valuable in enabling us to interpret observations.

In the first place the atmosphere of Mars is so much rarer than that of the earth that the most delicate observations by Campbell with the great spectroscope of the Lick Observatory have failed to show any evidence whatever of its existence. This does not prove that no atmosphere exists, because there are other sources of evidence; but in the opinion of Campbell it shows that the density of the atmosphere can not amount to one quarter that of the earth. This view is strengthened by the comparative rarity of clouds upon the planet. Portions of the surface are seemingly obscured by vapors from time to time, but this is rather exceptional in any one region.

The other point on which we have some light, apart from the revelations of the spectroscope, is that of the probable prevailing temperature. A reliable estimate of this important element in Martian meteorology has been possible only in recent times, since the law of radiation of heat has been determined. The reasoning on which the estimate is based is so simple that I shall venture to set it forth.

We all know that a hot body is continually radiating heat, so that fire in the chimney place will warm the opposite walls of the room even if the air is below the freezing point. We feel this radiation only in case of very hot bodies, like the coals or flame of a fire. But accurate experiments show that every body, however cold it may be, radiates heat when left to itself without receiving heat from any outside source.[1] For example, during the night the earth radiates heat into space hour by hour, so that, as a general rule, its surface grows cooler during the entire night. Exceptions occur only when a current of warm air sets in. We know that, during the polar winter, although the Arctic regions receive a little warm air from the temperate zone, the temperature continually falls through radiation into the sky, month after month, until it reaches a degree far below any ordinarily experienced in our latitudes. It follows that any heat thus radiated by a planet, like the earth or Mars, must be gained from some source, else the temperature will fall below any that we ever experience on the earth, even below that of liquid air.

There is practically only one source from which the necessary heat is derived either for the earth or for a planet. That source is the sun. True, a little heat is received from the stars and a little from the interior of the earth, but these amounts are so small as to be scarcely measurable. Now, suppose a perfectly cold planet like the earth or Mars exposed to the sun's rays, and set rotating on its axis while revolving around the sun in a regular orbit. It will gradually absorb heat from the sun and so rise in temperature. As the temperature rises, heat will be radiated at a rate which continually increases with the temperature, as we see in the case of the fire. A point will finally be reached at which the amount of heat radiated is equal to the total amount received from the sun. Then the temperature will become stationary. It follows that if we know how warm a body must be in order to radiate a certain amount of heat, and if we know how much heat it receives from the sun, we can approximately determine its temperature.

The sun's radiation upon the earth has been determined with as much certainty as the case admits of by several modern physicists, high among whom stands our late Professor Langley, Secretary of the Smithsonian Institution. The result of these observations may be exprest in the following way. Imagine a flat vessel 1 inch thick, of any cross dimensions, filled with water and covered over water-tight. We thus have something which may be shaped like a very thin box. The main points are that the thickness of the vessel is exactly 1 inch, that it is filled with water, and that one surface is blackened so that it absorbs all the heat which falls upon it. Let this surface be exposed to the rays of the sun as shown in the figure.[2] It is found that the amount of heat falling upon it will suffice to raise the temperature of the water 1° C., that is, about 1.8° F., in a minute. This, then, is the measure of the heat which the sun radiates to a planet as distant as ours. Knowing it for the distance of the earth, we can easily compute it for Mars, because the intensity diminishes as the square of the distance increases. When Mars is nearest the sun each square mile of its surface receives about half as much heat as the earth, and at the greatest distance about one-third as much. This has long been known, but only recently has the other part of the problem been solved—that of determining how warm the earth or Mars must be in order to radiate all the heat it receives. The temperature that is necessary to produce this effect was long greatly underestimated. A curious instance is afforded by Langley's estimate of the temperature of the moon. He supposed that a body radiating as little heat as the moon does must be far below the freezing point. But when the law of radiation was finally established, it was found that Langley's observations showed the temperature of the moon to be not strikingly different from that which prevails on the earth, tho it might be much higher under a noonday sun and much lower when turned away from the sun. Very interesting is the agreement of the computed result with the temperature of the earth. It was formerly thought that the atmosphere served as a sort of blanket to the earth, which allowed the sun's heat to pass thru it and reach us, but permitted only of a very small amount being radiated back. Probably there is some such blanketing effect, but it is much less than was supposed. In fact, when we calculate about what temperature the earth ought to have in the general average, to radiate all the heat it receives from the sun we find it to be not very different from the actual temperature. The same remark applies to the moon. We thus have what every physical philosopher desires when he draws conclusions from a theory—practical test of the latter. The law of radiation, tho seemingly well proved by observation, might have been subject to more or less doubt as a method of determining the temperature of a planet had it not been confirmed by the case of the earth. Being confirmed, we apply it with confidence to estimate the temperature of Mars. A simple calculation leads to the conclusion that the temperature of the surface of that planet must be everywhere below the freezing point of water, unless in its torrid zone, under a high sun.

Another conclusion from the rarity of the air is that the vicissitudes of temperatnre are there far greater than upon the earth. We have remarked that during our night the earth cools off by radiating into space the heat which it received from the sun the day previous. We also know that the clearer and dryer the air the greater is the fall of temperature, while the presence of clouds lessens the fall by interfering with radiation. The radiation and absorption of heat by the atmosphere are much less than by the earth, so that during the night the air gives back to the earth an important part of the heat which it has received from it during the day. But on Mars the air is so rare that during the night it offers little impediment to the radiation, and does not contain much heat to return to the surface of the planet. Moreover, in our Arctic regions, during the long polar night, the fall of temperature is lessened thru the intercommunication of the air by winds between the Frigid Zone and the warmer regions where the sun is shining. Now on Mars this feature also is wanting, and there is no such powerful agent to limit the fall of temperature in regions where the sun is not shining.

We, therefore, conclude that during the night of Mars, even in the equatorial regions, the surface of the planet probably falls to a lower temperature than any we ever experienced on our globe. If any water exists it must not only be frozen, but the temperature of the ice must be far below the freezing point. When, as the Martian morning appears, the sun's rays shine upon this cold region they can not begin to melt the ice until the temperature of the latter rises above the freezing point. This will take a much longer time than it will on the earth, because the heat received is, on the average, less than half as great as what we receive. Without going into detailed calculations, we may say that it is scarcely possible that more than one or two inches of ice could be melted

[1] The law followed is that the higher the temperature of a body the more rapidly it loses heat by radiation.

[2] Not reproduced here.

during a Martian day. Thus, while it is possible that under a noonday sun the temperature of the air and, perhaps, of the solid rock may rise above the freezing point of water, all the heat received must be completely lost when the sun sinks in the west. The most careful calculation shows that if there are any considerable bodies of water on our neighboring planet they exist in the form of ice, and can never be liquid to a depth of more than 1 or 2 inches, and that only within the torrid zone and during a few hours each day. We may claim with certainty that in the polar regions of Mars the temperature can never rise to anything near the freezing point of water.

Here a difficulty may at once occur to the critical reader. Are not the snow caps of Mars actually seen to melt away under the influence of the sun's rays? I reply in the negative. There is no evidence that snow like ours ever forms around the poles of Mars. It does not seem possible that any considerable fall of such snow could ever take place, nor is there any necesity of supposing actual snow or ice to account for the white caps. At a temperature vastly below any ever felt in Siberia, the smallest particles of moisture will be condensed into what we call hoarfrost, and will glisten with as much whiteness as actual snow. This is a familiar fact which requires no elucidation. We should expect hoarfrost to form around the poles of Mars if there is the slightest tinge of vapor in its thin invisible atmosphere. We do actually see this white formation.

But why does this hoarfrost disappear under the sun's rays if the temperature remains below the freezing-point? The reply is that, as physicists and meteorologists well know, snow and ice slowly evaporate even at the lowest temperature that can be produced. The rate of evaporation is so slow as to be unnoticed, except when very exact observations are made. We should, therefore, expect that in the absence of a perceptible atmosphere, when this thin coating of frost crystals, perhaps a millimeter in thickness, is exposed to the sun, it will gradually evaporate day after day, leaving the darker surface under it exposed. This is precisely what we see to take place. Thus, so far as the ordinary facts are concerned, there is nothing to surprise us in what we see going on upon Mars at so low a temperature. The higher elevations in the temperate and torrid zones of the planet would naturally now and then be covered by frost during the night, which might continue during the following day, or for a number of days. Thus we have a kind of Martian meteorological changes, very slight indeed and seemingly very different from those of our earth, but yet following similar lines on their small scale. For snowfall substitute frostfall; instead of feet or inches say fractions of a millimeter, and instead of storms or wind substitute little motions of an air thinner than that on the top of the Himalayas, and we shall have a general description of Martian meteorology.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Librarian.

The following have been selected from among the titles of books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be lent for a limited time to officials and employees who make application for them. Anonymous publications are indicated by a ——.

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RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Librarian.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——

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THE WEATHER OF THE MONTH.

By Mr. P. C. Day, Acting Chief, Climatological Division.

PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure for October, 1908, over the United States and Canada, is graphically shown on Chart VI, and the average values and departures from the normal are shown for each station in Tables I and III.

In general the main features of the pressure distribution were along the usual lines, high pressure penetrating well into the interior portions of the United States, from both the Atlantic and Pacific coasts, with diminishing pressure along both the northern and southern borders. High atmospheric pressure prevailed over the districts east of the Mississippi River and north of the Gulf States, with the crest over the Ohio Valley, Lake region, and New England, where the average for the month was slightly above 30.15 inches. To the southward pressure diminished rapidly with an average of but 29.90 inches over the southern portion of the Florida Peninsula.

Over the western districts a ridge of comparatively high mean pressure, slightly above 30.05 inches, extended from northern California to central Washington, and eastward to Wyoming with diminishing pressure northward and southward.

The average pressure was above the normal over all districts in the United States and Canada, except over the southern portion of Florida, the maximum excess, .10 to .14 inch occurring from the Lake region northeastward over New England, the St. Lawrence Valley, and the Maritime Provinces of Canada.

The pressure for October increased over that for the preceding month in all districts, except a slight decrease over a small area in western Texas and eastern New Mexico, and a sharp decrease over the western portions of Oregon and Washington. Over the Great Lakes the increase was about .10 inch and similar increases were shown along the west Gulf coast and over southwestern Arizona.

With high pressure dominant from the upper Ohio Valley northeastward to New England, the resulting winds along the Atlantic coast and over the east Gulf States were generally from the northeast, while over the Mississippi Valley, Lake region and westward to the Rocky Mountains they were as a rule from the south. Storm activity showed a considerable increase above the normal along the Atlantic coast and from the upper Lakes westward to the Rocky Mountains, and southwestward over the Great Plains and southern Rocky Mountain district to southern California, and also over Oregon and Washington, where the average velocities ranged from 10 to 50 per cent above the normal.

From northern New England southwestward in a rather narrow area over the lower Lakes, Ohio and lower Mississippi valleys to central Texas, the wind movement was generally less than the average, and a similar area extended from the northern Rocky Mountains southwestward to the middle Pacific coast.

TEMPERATURE.

The mean temperature during October, 1908, was above the normal from eastern North Dakota southeastward over the upper Mississippi Valley, Lake region, Ohio Valley, Middle Atlantic States, and New England, averaging about 3° per day above from the upper Lake region to New England.

There was a slight excess over portions of western Montana, Idaho, and eastern Washington, and near the coast of southern California. From the South Atlantic and east Gulf States westerly and northwesterly to the Pacific coast, except as noted above, the mean temperature for the month was generally below the normal, ranging from 3° to 5° below over the east Gulf and southern portions of the Rocky Mountain and Plateau districts.

During the first decade the mean temperature was below normal over all districts, except along the immediate Pacific coast and at a few points over the Great Plains States where it was normal or slightly above.

Over the lower Mississippi and Ohio valleys, Gulf and South Atlantic States the first ten days of the month were generally cold, due to the slow passage eastward of an extensive area of high pressure central over the upper Mississippi Valley, on the morning of the 1st, with resulting mean temperatures for the period ranging from 3° to 7° daily below the normal.

Some comparatively low temperatures occurred along the southern border from Texas to California, and minimum temperatures below freezing occurred in northern New England, the Appalachian Mountains, and from the upper Lakes westward to and including the greater part of the Rocky Mountain districts and at exposed points in Utah and Nevada.

Comparatively cold weather continued over the central valleys and all eastern districts until near the middle of the second decade when warmer weather set in over all districts east of the Rocky Mountains and continued without material interruption until near the close of the month.

The mean temperature during the second decade was above the normal from 3° to 9° per day over all districts from the eastern foot hills of the Rocky Mountains to the Atlantic, except over the South Atlantic and Gulf States where it ranged from slightly above over the northern to slightly below normal over the more southerly portions of those districts.

From the Rocky Mountains westward the weather was cool, the average for the decade ranging from 2° to 4° below the normal.

High day temperatures for the season of the year prevailed from the Great Plains eastward to the Atlantic, the maximum readings ranging from 80° to 90°.

Over the Pacific coast districts and in southern Arizona the minimum temperatures were unusually low.

During the third decade the temperature continued above normal over the districts east of the Mississippi until near the end of the month, when cooler weather set in, and the month closed with cold weather prevailing over all districts, except from the northern Rocky Mountains westward to Washington.

The mean temperature during this decade was decidedly low over the southern portions of the Great Plains, Rocky Mountain, and Plateau districts, where the average was from 5° to 10° per day below the normal.

Freezing temperatures and killing frosts extended as far south as central Texas and from thence northeasterly over the lower Ohio Valley and the Appalachian Mountains to southern New England, and over all western districts, except the lower elevations of southwestern Arizona, the valleys and coast districts of California, and over the portions of Oregon and Washington west of the Coast Range.

Temperatures below 20° were reported from points in northern New York and the interior of New England, from the upper Lakes westward to the Dakotas, and generally over the mountain and Plateau regions of the West.

PRECIPITATION.

Over the Atlantic coast districts and extending westward to the Appalachian Mountains the precipitation ranged from 2 to 4 inches, with amounts in excess of 6 inches on the coast and in the western portions of North Carolina and above 20 inches on the east coast of Florida. Amounts from 2 to 3 inches were general over most of the States between the Mississippi Valley and the Rocky Mountains, except over portions of southern and eastern Texas, the greater part of Louisiana, and Arkansas and eastern and central Missouri, with local amounts from 6 to 10 inches in portions of eastern Kansas, central Oklahoma, northern Texas, and western Missouri. Amounts from 2 to 4 inches occurred in the northern and central portions of the Rocky Mountain districts and over the Pacific coast from northern California northward.

From the Appalachian Mountains westward to the Mississippi Valley, and over Louisiana, Arkansas, and eastern Missouri, the rainfall for the month was generally less than 1 inch, and over an extensive area from southern Michigan to the coast of Louisiana, including the immediate lower Mississippi and Ohio valleys, the amounts were less than one-half inch, and at a number of points no measurable amount of precipitation occurred during the entire month.

The drought conditions that had prevailed over the Lake region, Ohio Valley, and adjoining districts, partially relieved by the general rains of the latter part of September, were continued during the greater part of the month over most of the above districts and extended southward into the lower Mississippi Valley, where the need of rain was also being felt.

Over much of the western portions of New York and Pennsylvania, parts of Ohio, West Virginia, Kentucky, Tennessee, Indiana, Illinois, and southern Michigan, the water supply at the end of the month was very low, many of the smaller springs and streams were dry, the larger streams greatly reduced in volume, and much inconvenience to industrial pursuits and suffering to animal life were being experienced thereby.

Precipitation was above the normal over the southern Appalachian Mountain district, in the southern portion of Florida, and generally over the Great Plains, northern and central Rocky Mountain and Plateau districts, and the north Pacific coast States, except extreme western Washington. Over the immediate south Atlantic and Gulf coasts, the Mississippi Valley, Lake region, and Middle Atlantic States there was a marked deficiency in precipitation.

SNOWFALL.

Some unusually heavy falls of snow, for the period of the year, were reported from the higher elevations of the southern Appalachian Mountains, over a restricted area in eastern Kansas, northwestern Missouri and southwestern Iowa, and generally over the Rocky Mountain region. Over portions of the Main Divide from northern New Mexico to the Canadian boundary amounts from 10 to more than 60 inches were reported, and heavy snows occurred also in the Cascade Mountains of Oregon.

The unusually early fall of such heavy snow with attendant high winds caused the loss of several human lives and heavy loss of life and great suffering among sheep and cattle in the northern portions of the Rocky Mountain district.

But little snow remained on the ground at the end of the month, except in the high elevations of the Rocky Mountains.

HUMIDITY AND SUNSHINE.

The distribution of the average relative humidity conformed in a marked degree to the rainfall distribution. It was above the normal over the south Atlantic coast and Florida Peninsula, and in the Great Plains and northern portions of the Rocky Mountains, Plateau and Pacific coast districts, the greatest excess, about 20 per cent, occurring over the northern Plateau.

Relative humidity was below the normal from New England southwestward over the Great Lakes, Ohio and Mississippi valleys and in the southwest, the greatest deficiencies, about 10 per cent, occurring in the lower Ohio and middle Mississippi valleys.

Much clear weather prevailed over portions of New England, the Gulf States, the lower portions of the Mississippi and Ohio valleys and generally in the southwest.

In the southern portions of Mississippi and Louisiana the amount of sunshine was about 80 per cent of the possible, and in portions of Arizona the sunshine was almost continuous. Along the northern border from the upper Lakes westward to Washington the sunshine was less than 40 per cent of the possible.

In Canada:—Director R. F. Stupart says:

During October warm weather predominated from Manitoba to the Maritime Provinces, and the mean temperature for that portion of Canada was from 1° to 5° above the normal. Maximal temperatures were very high, and in some parts of Ontario exceeded 80°. From Saskatchewan to British Columbia the mean temperature was subnormal, the difference from average being from 1° to 5°.

Among the marked features of the October weather were the large amount of precipitation over the Western Provinces and the continuance of severe drought from Ontario to the Maritime Provinces. With local exceptions in North Saskatchewan and Western Manitoba the amount registered in the Western Provinces was from 36 per cent to 200 per cent in excess of the normal, the fall being mostly rain but partly in the form of snow. From Ontario to the Maritime Provinces, with the exception of the Gaspé Peninsula of Quebec and locally in Southwestern Nova Scotia, where an amount in excess of the average was recorded, the total amount of the fall was generally much less than normal, and in some districts did not reach 20 per cent of the usual quantity.

Average temperatures and departures from the normal.

Districts.	Number of stations.	Average temperatures for the current month.	Departures for the current month.	Accumulated departures since January 1.	Average departures since January 1.
		°	°	°	°
New England	12	53.2	+ 2.6	+ 8.8	+ 0.9
Middle Atlantic	16	57.2	+ 2.0	+ 3.3	+ 0.3
South Atlantic	10	62.4	− 1.3	+ 6.0	+ 0.6
Florida Peninsula *	8	71.6	− 1.8	+ 5.3	+ 0.5
East Gulf	11	62.8	− 2.8	+ 7.0	+ 0.7
West Gulf	10	64.5	− 1.8	+11.4	+ 1.1
Ohio Valley and Tennessee	13	57.5	+ 0.5	+12.2	+ 1.2
Lower Lake	10	53.6	+ 2.0	+ 7.3	+ 0.7
Upper Lake	12	50.5	+ 2.9	+18.8	+ 1.9
North Dakota *	9	42.7	− 0.7	+19.8	+ 2.0
Upper Mississippi Valley	15	53.4	+ 0.6	+14.8	+ 1.5
Missouri Valley	12	52.2	− 0.5	+19.8	+ 2.0
Northern Slope	9	43.2	− 1.5	+ 7.4	+ 0.7
Middle Slope	6	54.0	− 1.5	+13.3	+ 1.3
Southern Slope *	7	60.4	− 2.0	+ 4.9	+ 0.5
Southern Plateau *	12	55.5	− 4.2	− 6.7	− 0.7
Middle Plateau *	10	45.1	− 3.6	− 7.8	− 0.8
Northern Plateau *	12	46.6	− 1.2	+ 4.6	+ 0.5
North Pacific	7	50.5	− 0.6	− 2.4	− 0.2
Middle Pacific	8	57.4	− 1.2	− 1.3	− 0.1
South Pacific	4	61.7	− 0.6	+ 4.2	+ 0.4

* Regular Weather Bureau and selected cooperative stations.

Average precipitation and departures from the normal.

Districts.	Number of stations.	Average.		Departure.	
		Current month.	Percentage of normal.	Current month.	Accumulated since Jan. 1.
		Inches.		*Inches.*	*Inches.*
New England	12	3.07	86	− 0.5	− 5.2
Middle Atlantic	16	2.89	91	− 0.3	− 1.4
South Atlantic	10	4.54	115	+ 0.6	+ 2.2
Florida Peninsula *	8	4.66	104	+ 0.2	− 1.5
East Gulf	11	1.57	57	− 1.2	− 2.0
West Gulf	10	1.19	43	− 1.6	+ 1.2
Ohio Valley and Tennessee	13	0.81	31	− 1.8	− 4.6
Lower Lake	10	1.48	50	− 1.5	− 2.6
Upper Lake	12	1.06	37	− 1.8	− 2.7
North Dakota *	9	1.52	136	+ 0.4	+ 0.7
Upper Mississippi Valley	15	1.18	48	− 1.3	− 0.8
Missouri Valley	12	3.46	402	+ 2.6	+ 3.9
Northern Slope	9	2.34	249	+ 1.4	+ 4.0
Middle Slope	6	2.67	170	+ 1.1	+ 5.7
Southern Slope *	7	3.10	163	+ 1.2	+ 5.8
Southern Plateau *	12	0.32	44	− 0.4	+ 0.1
Middle Plateau *	10	1.58	162	+ 0.6	+ 1.5
Northern Plateau *	12	1.63	133	+ 0.4	− 0.7
North Pacific	7	4.31	107	+ 0.3	− 4.1
Middle Pacific	8	1.24	93	− 0.1	− 4.5
South Pacific	4	0.27	31	− 0.6	− 1.3

* Regular Weather Bureau and selected cooperative stations.

Average cloudiness and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	5.0	− 0.5	Missouri Valley	5.0	+ 1.1
Middle Atlantic	4.6	− 0.2	Northern Slope	5.5	+ 1.3
South Atlantic	4.1	+ 0.1	Middle Slope	4.1	+ 1.0
Florida Peninsula	4.7	0.0	Southern Slope	3.0	+ 0.2
East Gulf	2.8	− 0.8	Southern Plateau	1.6	− 0.4
West Gulf	2.8	− 0.8	Middle Plateau	3.9	+ 0.7
Ohio Valley and Tennessee	3.8	− 0.7	Northern Plateau	6.0	+ 0.9
Lower Lake	4.6	− 1.2	North Pacific	6.5	− 0.6
Upper Lake	5.6	− 0.5	Middle Pacific	4.0	+ 0.8
North Dakota	6.1	+ 1.0	South Pacific	2.1	− 1.4
Upper Mississippi Valley	4.5	+ 0.1			

Average relative humidity and departures from the normal.

Districts.	Average.	Departure from the normal.	Districts.	Average.	Departure from the normal.
New England	78	− 1	Missouri Valley	68	+ 1
Middle Atlantic	76	0	Northern Slope	72	+12
South Atlantic	79	+ 1	Middle Slope	63	+ 4
Florida Peninsula	80	0	Southern Slope	61	− 2
East Gulf	68	− 5	Southern Plateau	40	− 7
West Gulf	68	− 4	Middle Plateau	53	+ 4
Ohio Valley and Tennessee	69	− 2	Northern Plateau	65	+ 2
Lower Lake	68	− 6	North Pacific	82	+ 2
Upper Lake	76	− 2	Middle Pacific	68	− 2
North Dakota	78	+ 6	South Pacific	61	− 9
Upper Mississippi Valley	68	− 3			

Maximum wind velocities.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
Bismarck, N. Dak	20	58	se.	North Head, Wash	19	64	nw.
Block Island, R. I	30	55	w.	Do	20	56	nw.
Do	31	50	w.	Do	29	52	se.
El Paso, Tex	18	50	nw.	Oklahoma, Okla	19	54	s.
Flagstaff, Ariz	2	58	sw.	Point Reyes Light, Cal.	1	90	nw.
Modena, Utah	15	56	sw.	Do	2	63	nw.
Mount Tamalpais, Cal	1	74	nw.	Do	16	50	nw.
Do	2	64	n.	Do	19	64	nw.
Do	17	52	n.	Do	20	68	nw.
Do	18	50	n.	Sand Key, Fla	3	51	ne.
Do	19	54	nw.	Southeast Farallon, Cal.	1	58	nw.
Mount Weather, Va	30	54	nw.	Do	2	56	n.
Nantucket, Mass	19	54	ne.	Do	20	51	nw.
Do	30	56	n.	Tatoosh Island, Wash	12	52	s.
North Head, Wash	1	53	nw.	Do	19	50	w.
Do	12	66	se.	Do	29	54	s.
Do	18	62	se.				

CLIMATOLOGICAL SUMMARY.

By Mr. P. C. DAY, Acting Chief, Climatological Division.

TEMPERATURE AND PRECIPITATION BY SECTIONS, OCTOBER, 1908.

In the following table are given, for the various sections of the Climatological Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting greatest and least monthly precipitation, and other data, as indicated by the several headings.

The mean temperatures for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have ten or more years of observation. Of course the number of such records is smaller than the total number of stations.

Section.	Temperature—in degrees Fahrenheit.								Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	60.4	− 3.4	Tuskegee	92	18	Riverton	27	31	1.76	− 0.86	Union Springs	3.24	Riverton	0.19
Arizona	60.0	− 4.1	Maricopa	110	1	Flagstaff, A	12	21	0.50	− 0.20	Natural Bridge	2.01	6 stations	0.00
Arkansas	59.2	− 2.8	Ozark	93	14	Pond	24	28	0.48	− 2.12	Pond	2.12	3 stations	0.00
California	58.3	− 2.1	Heber	109	9	Truckee	9	21, 22	1.37	− 0.48	Monumental	16.17	20 stations	0.00
Colorado	43.1	− 2.9	Lamar	96	16	Steamboat Springs	−15	23	2.17	+ 1.15	Steamboat Springs	5.97	Westcliffe	0.05
Florida	69.7	− 2.9	Orange City	93	3 d't's	Molino	33	30	3.16	− 0.93	Miami	27.86	Moline	T.
Georgia	61.3	− 2.9	Monticello	93	18	Gore, Woodbury	32	31	2.76	+ 0.76	Clayton	6.86	St. Marys	0.82
Hawaii † (September)	73.7	......	Kihei, Maui	93	9 d't's	Humuula, Hawaii	‡40	29	6.25	......	Olaa, Hawaii	26.01	Raymond's R'ch, Me.	0.00
Idaho	44.6	− 2.1	Orofino Garnet	85 85	9 10	Forney	3	22	2.34	+ 1.00	Burke	6.52	Emmett	0.48
Illinois	54.8	+ 0.4	Chester	91	18	Lanark	15	31	0.52	− 1.59	Galva	1.42	3 stations	0.00
Indiana	54.9	+ 0.2	Rome	93	20	Northfield	13	31	0.34	− 2.08	Hammond	1.46	Mt. Vernon, Zelma	T.
Iowa	51.1	− 0.8	4 stations	89	14, 16	Atlantic	17	12	3.38	+ 1.03	Lamoni	8.83	Clinton	0.58
Kansas	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Kentucky	57.1	− 0.8	Bardstown	92	20	Shelbyville	20	31	0.71	− 1.61	Middlesboro	2.94	Hopkinsville	0.00
Louisiana	63.6	− 3.9	Reserve	94	8	Minden Robeline	28 28	3 d't's 28, 29	0.49	− 2.42	Jennings	3.02	8 stations	0.00
Maryland and Delaware	57.5	+ 2.0	Laurel, Md	90	17	Deer Park, Md	15	3	2.28	− 0.83	Fallston, Md	4.26	Grantsville, Md	0.53
Michigan	51.2	+ 2.6	Charlotte	91	15	Omer	14	12	0.92	− 1.80	Adrian	2.37	Humboldt, W. Bra'ch	0.20
Minnesota	47.0	+ 0.9	Windom	89	14	Floodwood Pokegama Falls	11	31	1.93	− 0.39	Albert Lea	4.90	Black Duck	0.57
Mississippi	60.8	− 3.3	Batesville	82	20	Duck Hill	28	29	0.35	− 1.91	Bay Saint Louis	1.44	4 stations	0.00
Missouri	56.3	− 1.7	Parkville, Warsaw	92	17	Ironton	21	13	2.74	+ 0.31	Gallatin	9.33	3 stations	0.00
Montana	42.7	− 1.9	Fort Harrison Lewistown	82 82	1 11	St. Regis	− 2	22	2.28	+ 1.66	Snowshoe	9.99	Chinook	0.20
Nebraska	49.9	− 1.6	Kirkwood	94	15	Fort Robinson	9	23	2.66	+ 1.01	Tecumseh	4.64	Atkinson	0.41
Nevada	46.7	− 2.5	Elko	95	11	Hamilton	1	22	0.46	− 0.09	Aura	2.78	3 stations	0.00
New England*	52.1	+ 3.0	Waterbury, Conn	93	17	Grafton, N. H.	14	21	2.94	− 0.81	Hyannis, Mass	8.86	Plymouth, N. H	1.07
New Jersey	57.3	+ 2.9	Imlaystown	92	18	Charlotteburg	19	13	2.71	− 1.22	Flemington	5.14	Asbury Park	1.47
New Mexico	51.8	− 3.5	Carlsbad	92	18	Elizabethtown	−11	23	0.43	− 0.70	Rociada	1.80	10 stations	0.00
New York	52.2	+ 2.7	Addison Jeffersonville	90 90	16 17	Indian Lake	10	21	2.12	− 1.34	Liberty	4.69	Angelica	0.69
North Carolina	59.5	− 0.4	Tarboro Lumberton	90 90	16 17	Banners Elk	25	31	5.45	+ 1.96	Banners Elk	12.54	Moncure	2.13
North Dakota	43.0	− 0.6	Edgely	86	13	Manfred	8	30	1.58	+ 0.41	Goforth (Orange P. O)	4.01	Mayville	0.83
Ohio	54.1	+ 0.7	3 stations	90	3 d't's	3 stations	15	31	1.17	− 1.08	New Alexandria	2.68	Waynesville	0.27
Oklahoma	59.4	− 2.8	Woodward	98	19	Buffalo	19	28	5.62	+ 4.35	Meeker	16.45	Buffalo	0.38
Oregon	50.0	− 1.2	Glendale	94	7	Silver Lake	12	22	3.97	+ 1.28	Glenora	11.84	Huntington	0.09
Pennsylvania	54.6	+ 2.8	Derry Station	93	16	3 stations	19	13, 21	1.95	− 1.50	Pocono Lake	5.48	Confluence	0.08
Porto Rico	77.6	......	Fajardo	98	24	Aibonito	54	15	5.13	......	Central Ingenio	8.72	Canovanas	1.95
South Carolina	62.0	− 1.4	Dillon, Waterboro	89	19	Bowman	35	30	4.22	+ 1.47	Conway	9.42	Waterboro	1.41
South Dakota	47.4	− 1.2	Spearfish	95	15	Faulkton	8	29	2.30	+ 0.86	Philip	4.54	Gannvalley	0.78
Tennessee	57.5	− 1.5	Dover	95	21	Rugby	23	31	1.15	− 1.41	Birds Bridge	5.64	2 stations	0.00
Texas	65.2	− 2.3	Uvalde	98	6	3 stations	20	27, 30	1.79	− 0.76	Abilene	6.96	Beaumont	T.
Utah	44.8	− 4.0	St. George	94	13	Park City	− 5	24	2.22	+ 1.48	Ogden, No. 1	4.94	Lucin	0.20
Virginia	56.9	+ 0.4	Lincoln	92	17	Burkes Garden	16	31	3.67	+ 0.44	New Castle	8.54	Cape Henry	1.60
Washington	49.5	− 1.0	Colville	90	9	Northport	18	22	3.33	+ 0.50	Quiniault	10.72	Twisp	0.59
West Virginia	55.1	+ 0.2	Moorfield	91	17	Arborvale	16	31	1.60	− 0.80	Princeton	6.88	Rowlesburg Elkins	0.33 0.33
Wisconsin	49.5	+ 1.3	Sauk City	85	14	Medford	9	30	1.38	− 1.21	Barron	3.08	Antigo	0.41
Wyoming	40.5	− 2.5	Pine Bluff	89	1	Norris, Y. N. P	− 1	18	1.89	+ 0.84	Lake Yellowstone	9.79	Basin	0.43

* Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. † 51 stations, average elevation, 576 feet. ‡ Data incomplete.

DESCRIPTION OF TABLES AND CHARTS.

By Mr. P. C. DAY, Acting Chief, Climatological Division.

For description of tables and charts see page 8 of REVIEW for January, 1908.

TABLE I.—*Climatological data for U. S. Weather Bureau stations, October, 1908.*

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.					
New England.							53.2	+ 2.6										78	3.07	− 0.5										5.0	
Eastport	76	69	85	30.01	30.10	+ .10	50.8	+ 4.2	75	18	58	30	31	43	24	46	42	78	4.09	+ 0.2	7	7,418	sw.	48	e.	27	10	9	12	5.5	T.
Greenville	1,070	6																													
Portland, Me.	103	81	117	30.02	30.14	+ .10	51.6	+ 2.5	80	17	60	28	13	43	34	46	41	74	3.65	0.0	7	6,052	w.	36	nw.	12	17	4	10	4.0	T.
Concord	288	70	79	29.84	30.16	+ .11	50.4	+ 1.7	85	18	64	22	13	37	49				1.62	− 1.6	6	2,931	nw.	24	nw.	30	18	5	8	3.8	T.
Burlington	404	12	47	29.71	30.16	+ .12	50.4	+ 0.8	78	16	61	25	21	40	39				1.95	− 1.2	7	7,953	s.	37	w.	31	14	2	15	5.9	T.
Northfield	876	16	70	29.22	30.18	+ .14	46.4	+ 2.8	80	16	60	19	21	33	45	41	39	86	1.99	− 0.5	9	5,248	s.	31	nw.	30	12	7	12	5.5	0.4
Boston	125	115	188	30.01	30.14	+ .09	55.4	+ 3.1	80	18	63	35	31	48	28	49	45	73	3.70	− 0.2	7	6,719	nw.	35	n.	30	15	6	10	4.9	0
Nantucket	12	14	90	30.10	30.11	+ .06	57.0	+ 2.5	74	16	62	39	31	52	18	53	50	83	4.97	+ 1.6	8	11,283	ne.	56	n.	30	10	10	11	5.9	0
Block Island	26	11	46	30.10	30.13	+ .08	56.6	+ 1.3	76	18	61	38	31	52	17	52	49	80	5.17	+ 1.1	8	11,786	ne.	55	w.	30	11	7	13	5.6	T.
Narragansett		9					53.8	+ 1.7	80	18	63	26	13	44	32				5.24		8		e.				20	3	8		
Providence	160	57	67	29.98	30.15	+ .10	55.3	+ 3.1	85	18	66	31	13	45	32	49	45	76	3.37	− 0.5	8	4,392	nw.	26	w.	31	17	6	8	4.2	0
Hartford	159	122	140	29.97	30.15	+ .09	54.8	+ 3.6	90	17	66	30	21	43	43	48	44	77	1.67	− 2.2	8	4,448	n.	33	nw.	30	12	8	11	5.7	T.
New Haven	106	116	155	30.02	30.14	+ .08	56.3	+ 3.5	89	17	66	32	13	46	40	50	45	73	1.58	− 2.3	8	6,504	n.	37	nw.	30	13	11	7	4.3	T.
Mid. Atlantic States.							57.2	+ 2.0										76	2.89	− 0.3										4.6	
Albany	97	102	115	30.06	30.17	+ .11	53.6	+ 3.2	84	16	64	29	21	43	40	47	43	77	2.07	− 0.9	6	4,121	s.	28	ne.	19	7	16	8	5.7	T.
Binghamton	871	78	90	29.24	30.18	+ .12	51.5	+ 2.3	81	16	63	25	21	40	42				2.31	− 0.8	9	3,884	se.	27	nw.	30	11	7	13	5.3	T.
New York	314	108	350	29.80	30.13	+ .07	54.6	+ 4.0	84	17	66	38	31	53	25	53	48	70	1.92	− 1.8	9	8,470	ne.	50	nw.	30	14	6	11	4.5	0
Harrisburg	374	94	104	29.76	30.16	+ .08	56.9	+ 2.9	86	17	66	33	13	48	34	50	45	74	4.15	+ 1.2	8	4,718	nw.	33	nw.	30	16	6	9	4.2	0
Philadelphia	117	116	184	30.03	30.15	+ .08	60.6	+ 3.3	85	18	68	40	31	53	29	53	49	71	1.81	− 1.3	10	7,083	nw.	37	n.	29	14	5	12	4.7	0
Scranton	805	111	119	29.30	30.17	+ .10	54.0	+ 2.6	87	17	65	30	13	43	38	47	43	73	2.29	− 0.6	9	4,295	ne.	25	nw.	2	13	4	14	5.4	T.
Atlantic City	52	37	48	30.08	30.14	+ .07	59.5	+ 2.1	83	16	66	36	31	53	29	54	50	76	3.18	− 0.1	5	6,208	ne.	32	ne.	29	14	4	13	4.9	
Cape May	17	48	52																												
Baltimore	123	100	113	30.01	30.14	+ .06	59.8	+ 2.3	85	17	68	39	13	51	33	53	49	72	2.59	− 0.4	8	5,390	n.	28	nw.	2	15	7	9	4.4	0
Washington	112	59	76	30.02	30.14	+ .06	58.2	+ 1.6	86	17	69	34	13	48	39	51	48	80	1.71	− 1.4	7	4,643	nw.	31	nw.	30	17	6	8	4.1	
Cape Henry	18	9	58																												
Lynchburg	681	83	88	29.41	30.16	+ .07	57.2	+ 0.3	88	17	69	34	13	45	42	50	48	83	3.52	+ 0.1	7	2,381	ne.	18	nw.	30	17	6	8	4.6	
Mount Weather	1,725	10	54	28.31	30.14	+ .05	54.0	+ 2.5	77	17	61	32	31	47	24	48	14	74	3.24	+ 0.8	7	9,079	nw.	54	nw.	30	18	5	8	3.8	
Norfolk	91	102	111	30.01	30.11	+ .04	62.6	+ 1.3	80	16	68	40	31	57	31	57	54	79	2.36	− 1.6	6	7,518	ne.	33	nw.	30	11	9	11	5.0	
Richmond	144	145	153	29.99	30.14	+ .06	60.4	+ 0.6	84	17	70	38	31	51	37				2.87	− 0.4	6	5,130	n.	26	n.	2	15	8	8	4.0	
Wytheville	2,293	40	47	27.75	30.15	+ .06	52.7	− 0.9	80	18	65	28	31	40	43	47	45	88	6.50	+ 3.4	6	2,725	e.	24	nw.	29	19	3	9	3.7	T.
S. Atlantic States.							62.4	− 1.3										79	4.54	+ 0.6										4.1	
Asheville	2,255	53	75	27.77	30.14	+ .05	54.2	− 1.1	82	19	67	31	4	42	42	47	43	76	7.27	+ 4.3	5	4,407	se.	32	e.	9	19	3	9	3.8	1.7
Charlotte	773	68	76	29.28	30.12	+ .04	59.5	− 1.6	82	19	69	41	14	50	31	52	47	72	6.58	+ 3.4	8	4,753	ne.	22	ne.	23	18	6	7	3.5	0
Hatteras	11	12	47	30.04	30.05	− .01	65.8	− 0.2	75	27	70	49	31	62	19	62	61	90	9.29	+ 3.3	11	12,013	ne.	44	nw.	30	16	7	8	4.7	0
Manteo							63.9		80	16	69	43	31	58					5.46	− 0.6	8		ne.				17	6	8		0
Raleigh	376	71	79	29.70	30.10	+ .03	60.8	+ 0.3	84	17	70	40	31	51	31	53	49	73	3.76	+ 0.3	7	5,923	ne.	26	ne.	22	18	3	10	4.1	0
Wilmington	78	81	91	29.98	30.07	+ .01	63.5	+ 0.2	83	19	72	45	31	55	30	57	54	81	5.74	+ 2.0	11	5,899	n.	27	e.	23	12	9	10	4.7	
Charleston	48	14	92	30.00	30.05	− .01	65.4	− 1.7	82	19	73	47	30	58	24	59	56	79	1.55	− 2.4	5	8,047	n.	30	n.	2	15	8	8	4.0	
Columbia, S. C.	351	41	57	29.70	30.09	+ .02	61.5	− 2.5	85	19	72	42	30	51	35	53	48	70	2.92	+ 0.1	8	5,014	ne.	21	ne.	3	18	6	7	3.9	
Augusta	180	89	97	29.89	30.08	+ .01	61.7	− 1.9	85	19	73	42	30	51	34	54	51	78	3.06	+ 0.7	8	4,440	ne.	22	ne.	21	18	6	7	3.6	
Savannah	65	81	89	29.99	30.06	+ .01	64.8	− 1.5	82	18	73	44	30	56	25	58	55	79	1.34	− 2.2	5	4,988	n.	23	sw.	28	16	5	10	4.1	
Jacksonville	43	101	129	29.98	30.03	+ .01	67.0	− 2.6	82	18	74	48	30	60	25	63	61	88	2.97	− 2.1	6	7,387	ne.	31	ne.	13	14	8	9	4.6	
Florida Peninsula.							74.6	− 1.5										80	7.70	+ 1.9										4.7	
Jupiter	28	10	48	29.91	29.94	− .02	74.8	− 2.0	85	9	80	56	30	70	17	70	68	82	20.43	+11.0	17	9,549	ne.	48	nw.	28	7	15	9	5.8	
Key West	22	10	53	29.90	29.92	− .02	77.2	− 1.5	86	1	82	67	30	73	15	72	69	79	6.29	+ 0.9	10	7,655	ne.	30	ne.	3	15	7	9	4.6	
Sand Key	25	41	71	29.87	29.90	− .04	77.3		85	7	81	66	30	74	14				2.90	− 2.5	7	13,472	ne.	51	ne.	3	14	9	8	4.9	
Tampa	35	79	96	29.96	30.00	− .02	71.7	− 0.9	85	26	81	51	31	63	24	64	62	79	1.18	− 1.8	6	6,781	ne.	34	sw.	9	17	9	5	3.6	
East Gulf States.							62.8	− 2.8										68	1.57	− 1.2										2.8	
Atlanta	1,174	190	216	28.86	30.10	+ .03	60.6	− 1.8	82	18	70	43	30	52	27	52	45	64	3.63	+ 1.3	6	7,298	ne.	36	nw.	29	20	4	7	3.7	
Macon	370	78	87	29.69	30.09	+ .03	61.0	− 2.7	84	18	72	42	15	50	36				2.54	+ 0.4	6	4,796	ne.	23	nw.	29	21	3	7	3.1	
Thomasville	273	8	58	29.76	30.06	+ .02	63.8	− 4.4	88	20	77	41	15	51	39	56	53	78	1.81	− 1.6	5	3,561	ne.	19	w.	29	21	3	7	3.0	
Pensacola	56	79	96	30.01	30.07	+ .04	65.6	− 3.8	83	1	74	45	29	57	27				0.93	− 3.2	3	6,773	ne.	26	nw.	9	24	2	5	2.0	
Anniston	741	9	58	29.33	30.13	+ .06	59.4	− 3.0	84	19	72	35	30	46	40				2.18	− 0.2	5	3,654	se.	25	se.	20	21	2	8	3.1	
Birmingham	700	11	48	29.35	30.12	+ .05	62.3	− 2.1	87	19	73	39	25	51	34	52	46	66	1.22	− 1.1	4	4,161	e.	18	se.	3	17	6	8	4.1	
Mobile	57	98	106	30.01	30.07	+ .03	65.4	− 1.7	86	19	76	45	29	55	29	56	50	67	0.33	− 2.8	2	4,713	nw.	31	nw.	8	23	7	1	2.0	
Montgomery	223	100	112	29.84	30.10	+ .04	62.1	− 3.6	84	19	74	44	30	50	35	52	46	63	3.08	+ 0.6	4	4,113	ne.	20	nw.	29	20	4	7	3.0	
Meridian	375	84	93	29.70	30.10	+ .04	59.6	− 3.4	85	20	74	33	25	46	38	51	47	72	0.73	− 2.0	4	3,061	e.	18	nw.	9	23	2	6	2.3	
Vicksburg	247	62	74	29.83	30.11	+ .05	63.0	− 2.3	85	20	74	41	29	52	34	53	48	66	0.04	− 2.8	2	4,206	n.	20	w.	23	23	5	3	2.0	
New Orleans	51	88	121	30.02	30.07	+ .04	67.7	− 1.8	84	20	75	52	29	60	21	59	55	72	0.78	− 2.2	3	5,455	ne.	25	nw.	8	23	6	2	2.1	
West Gulf States.							64.5	− 1.8										68	1.19	− 1.6										2.8	
Shreveport	249	77	84	29.83	30.10	+ .05	63.2	− 2.4	83	20	75	36	24	52	30	54	48	68	T.	− 3.2	0	4,267	se.	21	ne.	8	20	9	2	2.6	
Bentonville	1,303	11	44	28.71	30.09	+ .04	56.5	− 1.5	82	17	69	29	12	44	37				0.92	− 1.9	5	4,689	se.	24	s.	16	19	7	5	3.1	
Fort Smith	457	79	94	29.59	30.08	+ .03	60.2	− 1.5	84	17	72	35	24	49	34	52	46	68	1.33	− 1.5	3	6,001	e.	29	s.	16	19	8	4	3.0	
Little Rock	357	139	147	29.73	30.11	+ .05	60.6	− 2.3	82	21	71	38	24	50	32	51	45	64	0.43	− 2.1	2	5,775	e.	25	nw.	26	21	5	5	2.7	
Brownsville	57	4																													
Corpus Christi	20	48	53	30.03	30.05	+ .05	71.4	− 1.2	86	8	78	48	28	65	26	64	60	73	0.42	− 1.6	5	6,937	se.	28	se.	21	23	7	1	2.3	
Fort Worth	670	106	114	29.36	30.07	+ .04	64.4	− 1.9	88	17	76	38	24	53	40				4.49	+ 2.0	8	7,802	se.	31	n.	23	20	7	4	2.9	
Galveston	54	106	112	30.03	30.10	+ .07	69.6	− 2.8	80	1	74	49	24	65	20	62	57	69	0.34	− 3.8	4	7,754	se.	36	nw.	22	21	7	3	2.6	
Palestine	510	73	79	29.54	30.08	+ .05	64.8	− 1.4	84	4	75	38	24	54	31	55	50	69	1.15	− 2.4	6	3,322	ne.	10	n.	22	18	4	9	3.6	
San Antonio	701	80	91	29.31	30.04	+ .03	68.1	− 1.1	91	17	80	38	24	56	35	58	53	68	1.47	0.0	5	4,827	se.	28	nw.	23	17	9	5	3.2	
Taylor	583	55	63	29.46	30.06	+ .04	66.2	− 2.1	90	17	78	38	24	54	33				1.36	− 1.2	5	5,585	se.	27	nw	22	21	6	4	2.4	
Ohio Val. and Tenn.							57.5	+ 0.5										69	0.81	− 1.8										3.8	
Chattanooga	762	106	112	29.32	30.14	+ .05	59.4	− 1.4	83	19	71	40	26	48	37	51	48	77	1.73	− 1.1	5	3,399	s.	21	ne.	9	19	5	7	3.6	
Knoxville	1,004	93	100	29.06	30.13	+ .04	58.0	− 0.1	81	19	69	38	31	47	36	50	45	72	2.57	0.0	7	2,728	ne.	17	nw.	1	20	5	6	3.9	
Memphis	399	76	97	29.71	30.14	+ .07	61.1	− 1.4	86	19	71	40	28	51	30	53	49	70	0.05	− 2.7	1	5,554	n.	36	sw.	23	22	3	6	2.3	
Nashville	546	79	91	29.55	30.14	+ .06	59.2	− 1.1	85	20	71	37	25	47	37	51	47	73	0.44	− 2.0	3	3,252	nw.	22	s.	26	16	9	6	4.1	
Lexington	989	75	102	29.08	30.15	+ .07	57.6	+ 1.1	84	5	68	32	31	47	32				0.72	− 1.5	2	6,384	s.	24	nw.	29	16	6	9	4.0	
Louisville	525	111	132	29.56	30.15	+ .07	59.4	+ 1.0	86	5	71	33	31	48	38	48	40	60	0.07	− 2.6	3	4,954	n.	26	ne.	9	21	3	7	2.7	
Evansville	431	72	82	29.65	30.12	+ .04	58.4	+ 0.4	84	19	69	34	31	48	34				0.28	− 2.8	1	4,577	s.	30	s.	25	19	9	3	2.8	
Indianapolis	822	154	164	29.25	30.14	+ .07	55.8	+ 0.8	82	18	66	31	31	45	31	46	39	61	0.23	− 2.6	3	6,503	ne.	32	s.	25	14	9	8	4.5	
Cincinnati	628	152	160	29.47	30.16	+ .08	57.8	+ 0.8	85	5	69	33	31	46	39	47	39	59	0.35	− 2.0	4	4,057	se.	26	nw.	7	19	8	4	3.3	
Columbus	824	173	224	29.27	30.16	+ .08	55.6	+ 1.5	84	6	66	28	31	45	35	46	40	64	1.20	− 1.2	7	7,744	se.	32	nw.	7	19	8	4	3.1	
Pittsburg	842	336	352	29.25	30.17	+ .09	56.6	+ 1.7	80	16	67	34	3	46	39	48	43	66	0.95	− 1.4	7	5,502	ne.	32	nw.	30	15	6	10	4.3	
Parkersburg	638	77	84	29.50	30.16	+ .08	56.8	+ 2.2	85			26	31	45	45	48	44	74	1.57	− 0.9	6	2,933	ne.	19	nw.	1	13	11	7	3.5	
Elkins	1,940	41	50	28.11	30.20	+ .10	52.4	+ 1.0	81	17	67	23	31	38	49	44	42	83	0.33	− 2.1	4	2,033	n.	16	w.	30	15	5	11	5.2	
Lower Lake Region.							53.6	+ 2.0										68	1.48	− 1.5										4.6	
Buffalo	767	178	206	29.32	30.16	+ .11	54.0	+ 2.5	79	6	61	33	31	47	31	48	43	70	0.98	− 2.6	7	8,462	s.	36	sw.	14	14	10	7	4.1	T.
Canton	448	10	71	29.68	30.16		49.5	+ 2.3	80	17	60	24	21	38	43				1.71	− 1.6	8	6,823	sw.	32	sw.	13	14	10	7	4.4	T.
Oswego	335	76	91	29.78	30.15	+ .10	52.8	+ 1.6	79	17	62	32	13	44	35	47	42	72	1.62	− 1.7	7	7,263	s.	28	w.	19	14	7	10	4.5	T.
Rochester	523	81	102	29.60	30.18	+ .13	54.3	+ 3.5	81	18	63	33	31	46	34	47	42	69	1.28	− 1.6	11	5,322	sw.	26	nw.	30	13	8	10	5.0	0.5
Syracuse	597	97	113	29.51	30.16	+ .10	53.8	+ 2.8	80	17	63	33	31	45	33				2.78	− 0.4	9	6,978	s.	37	nw.	30	12	6	13	5.4	T.
Erie	713	92	102	29.38	30.15	+ .10	54.9	+ 1.8	81	6	62	37	31	47	28	47	41	63	1.53	− 2.3	9	7,549	s.	36	se.	24	13	7	11	5.2	0
Cleveland	762	190	201	29.33	30.16	+ .10	54.8	+ 1.7	81	15	63	36	13	47	32	48	42	67	1.07	− 1.7	5	10,607	se.	35	nw.	30	12	9	10	4.7	T.
Sandusky	629	62	70	29.47	30.16	+ .10	54.7	+ 0.8	82	15	63	37	3	47	29				0.97	− 1.5	5	5,823	s.	23	nw.	1	16	6	9	4.1	0
Toledo	628	207	246	29.47	30.16	+ .10	53.9	+ 1.3	82	18	63	34	2	45	31				1.34	− 0.9	6	9,281	sw.	30	w.	7	18	7	6	3.5	0
Detroit	730	218	258	29.36	30.16	+ .11	53.8	+ 2.1	78	15	62	31	30	45	28	47	41	70	1.49	− 0.9	6	9,244	s.	34	s.	16	13	6	12	5.1	0

TABLE I.—*Climatological data for U. S. Weather Bureau stations, October, 1908*—Continued.

Stations.	Elevation of instruments.			Pressure, in inches.			Temperature of the air, in degrees Fahrenheit.												Precipitation, in inches.			Wind.									
	Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with .01, or more.	Total movement miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
Upper Lake Region.							50.5	+ 2.9										76	1.06	− 1.8										5.6	
Alpena	609	13	92	29.46	30.14	+ .11	49.6	+ 3.7	83	15	58	24	12	42	35	44	41	79	0.98	− 2.4	5	8,470	sw.	34	se.	20	14	8	9	4.6	T.
Escanaba	612	40	82	29.44	30.11	+ .10	47.9	+ 2.8	63	15	54	28	30	42	23	44	41	80	0.89	− 2.2	7	8,219	s.	26	e.	24	5	8	18	6.9	T.
Grand Haven	632	54	92	29.43	30.12	+ .09	51.4	+ 1.2	77	5	60	30	12	43	36	45	41	74	0.90	− 1.6	4	8,418	s.	29	s.	13	14	11	6	4.2	T.
Grand Rapids	707	121	162	29.37	30.14	+ .10	53.2	+ 3.1	79	15	63	32	12	43	35	45	39	68	0.39	− 2.2	2	7,333	s.	30	sw.	15	9	13	9	5.2	
Houghton	668	66	74	29.32	30.06	+ .06	49.6	+ 4.5	87	15	57	27	31	42	37				1.11	− 2.1	10	5,195	e.	24	w.	6	3	14	14	6.9	0.1
Marquette	734	77	116	29.28	30.09	+ .08	49.8	+ 4.1	82	15	57	31	31	42	34	43	38	71	1.06	− 2.1	13	8,908	s.	44	sw.	3	4	9	18	7.1	2.8
Port Huron	638	70	120	29.45	30.15	+ .11	52.0	+ 2.5	80	18	62	29	12	43	35	45	41	75	0.73	− 2.0	5	8,080	sw.	33	nw.	31	13	8	10	4.7	
Sault Sainte Marie	614	40	61	29.43	30.14	+ .13	48.4	+ 5.4	77	15	56	23	31	41	27	43	40	83	1.27	− 2.0	8	6,692	e.	30	w.	29	2	12	17	7.4	1.4
Chicago	823	140	310	29.23	30.12	+ .08	55.2	+ 2.0	82	21	62	34	31	48	27	49	45	73	0.81	− 1.7	6	10,670	sw.	36	sw.	16	14	10	7	4.4	
Milwaukee	681	122	139	29.38	30.13	+ .10	51.6	+ 1.4	80	15	59	29	31	44	30	46	42	77	1.08	− 1.3	7	7,864	sw.	36	s.	16	16	10	5	3.8	
Green Bay	617	49	86	29.41	30.08	+ .06	51.2	+ 4.1	80	15	60	27	30	43	30	44	39	70	0.57	− 1.8	7	8,056	s.	30	n.	11	9	11	11	5.9	
Duluth	1,133	11	47	28.81	30.05	+ .05	45.8	+ 0.6	79	14	53	21	31	38	31	42	39	85	2.97	+ 0.2	8	11,093	sw.	43	ne.	19	7	16	8	5.5	
North Dakota.							43.2	+ 0.6										78	1.44	+ 0.2										6.1	
Moorhead	940	8	57	29.00	30.03	+ .03	45.4	+ 2.6	80	14	54	20	30	36	38	40	38	82	0.93	− 1.1	7	7,250	se.	30	se.	20	10	7	14	5.7	
Bismarck	1,674	8	57	28.23	30.04	+ .05	43.9	− 0.2	80	14	55	20	24	32	41	37	33	75	1.81	+ 0.8	4	9,182	n.	58	se.	20	8	10	13	6.1	0.3
Devils Lake	1,482	11	44	28.40	30.00	+ .01	41.6	+ 1.1	78	14	51	13	30	32	36	36	32	76	1.22	0.0	6	10,078	se.	40	se.	20	8	9	14	6.3	0.6
Williston	1,875	14	56	27.98	29.99	+ .01	42.0	− 0.9	74	14	52	20	23	32	42	36	32	78	1.81	+ 1.0	9	7,749	n.	41	w.	21	9	6	16	6.3	0.3
Upper Miss. Valley.							53.4	+ 0.6										68	1.18	− 1.3										4.5	
Minneapolis		102	208				49.1		79	14	57	23	30	41	30				2.27	− 0.3	9	9,890	nw.	40	se.	2	11	9	11	5.3	
St. Paul	837	171	179	29.13	30.04	+ .03	49.2	+ 1.1	79	15	58	24	30	41	30	42	36	68	2.19	− 0.2	9	8,430	s.	36	s.	16	10	14	7	4.9	
La Crosse	714	10	49	29.29	30.07	+ .05	50.6	+ 0.7	78	17	60	23	31	41	35				1.28	− 1.2	9	4,114	s.	19	s.	16	11	8	12	5.5	
Madison	974	70	78	29.04	30.10	+ .07	50.9	+ 2.1	78	15	60	28	31	42	31	43	38	69	0.64	− 1.8	5	7,746	s.	34	s.	16	13	11	7	4.5	
Charles City	1,015	10	49	28.98	30.08	+ .06	49.8	+ 1.6	79	15	60	23	31	41	33	43	39	77	2.63	+ 0.6	9	6,018	s.	28	sw.	16	8	11	12	5.8	T.
Davenport	606	71	79	29.42	30.09	+ .05	53.6	+ 1.0	81	15	64	30	31	44	32	46	40	68	0.87	− 1.5	5	5,588	s.	29	s.	15	17	6	8	4.0	T.
Des Moines	861	84	101	29.13	30.05	+ .02	52.9	+ 0.4	84	14	63	31	12	43	32	45	40	69	3.68	+ 1.0	7	7,129	sw.	38	sw.	16	12	10	9	5.3	
Dubuque	698	100	117	29.34	30.10	+ .06	51.7	− 0.3	79	15	61	26	31	42	33	45	40	70	1.20	− 1.5	9	4,288	se.	24	se.	16	16	4	11	4.8	
Keokuk	614	64	77	29.42	30.10	+ .05	54.4	− 0.1	85	14	64	31	31	45	32	46	40	68	0.87	− 1.6	7	5,514	nw.	28	sw.	24	20	4	7	3.6	
Cairo	356	87	93	29.74	30.13	+ .06	58.8	− 0.3	84	19	69	37	31	48	32	49	43	64	0.02	− 2.6	1	5,486	s.	29	sw.	25	19	6	6	3.5	
La Salle	536	56	64	29.55	30.13	+ .09	53.8	+ 1.9	83	21	65	25	31	42	39				0.41	− 2.2	3	5,497	sw.	26	sw.	21	14	9	8	4.4	
Peoria	609	11	45	29.45	30.12	+ .07	54.1	+ 2.1	85	14	66	24	31	42	40	45	39	69	0.71	− 1.9	4	5,689	s.	27	sw.	15	16	9	6	4.3	
Springfield, Ill.	644	10	92	29.41	30.11	+ .06	55.2	+ 0.6	82	14	66	29	31	44	35	46	39	62	0.29	− 2.3	6	6,508	s.	26	s.	16	22	4	5	3.0	
Hannibal	534	75	109	29.51	30.09	+ .04	55.0	− 0.9	87	14	65	31	12	45	34				0.43	− 1.2	6	7,351	sw.	34	s.	16	19	2	10	4.1	
St. Louis	567	208	217	29.49	30.10	+ .04	57.8	− 0.6	84	14	67	35	31	48	32	48	41	61	0.21	− 2.2	3	6,795	s.	34	sw.	24	15	9	7	4.2	
Missouri Valley.							52.2	− 0.5										68	3.46	+ 2.5										5.0	
Columbia, Mo.	784	11	84	29.25	30.08	+ .03	55.6	+ 0.8	86	17	66	29	12	45	36				0.91	− 1.5	6	6,085	s.	24	s.	20	16	5	10	4.4	T.
Kansas City	968	116	181	29.02	30.06	+ .02	55.7	− 0.1	85	17	65	32	24	47	29	48	42	69	8.47	+ 6.3	9	10,659	s.	45	s.	15	16	7	8	4.3	3.0
Springfield, Mo	1,324	98	104	28.68	30.10	+ .05	56.0	− 1.3	82	17	66	32	24	46	33	48	42	68	1.11	− 1.7	7	8,493	se.	34	w.	24	21	3	7	3.0	T.
Iola	984	11	50	29.03	30.08	+ .04	56.4	− 0.5	84	17	68	30	12	45	37				8.72	+ 6.4	11	6,559	s.	30	sw.	16	13	6	12	5.2	T.
Topeka		85	89				55.0	− 1.3	86	14	65	31	28	45	35				4.23	+ 2.3	9	8,917	s.	44	sw.	16	15	8	8	4.3	7.1
Lincoln	1,189	11	84	28.76	30.04	+ .01	52.8	− 0.5	86	14	63	29	30	43	34	44	39	70	2.34	+ 0.5	7	9,655	se.	45	sw.	19	14	7	10	4.8	T.
Omaha	1,105	115	121	28.85	30.04	+ .01	53.1	− 1.1	85	14	62	32	30	45	29	46	41	71	1.92	− 0.4	6	7,720	s.	38	nw.	24	14	7	10	4.8	T.
Valentine	2,598	47	54	27.29	30.03	+ .02	47.0	− 1.5	88	14	60	17	23	34	45	39	31	65	2.64	+ 1.3	3	8,826	nw.	48	sw.	19	13	13	5	4.2	
Sioux City	1,135	96	164	28.82	30.04	+ .02	49.6	− 1.5	82	16	58	28	11	41	35				2.80	+ 1.0	6	10,841	nw.	48	s.	19	10	7	14	5.7	T.
Pierre	1,572	70	75	28.34	30.02	+ .01	49.8	+ 0.7	90	14	61	24	24	38	47	40	32	59	3.21	+ 2.4	4	8,017	nw.	48	se.	20	10	11	10	5.2	
Huron	1,306	56	67	28.63	30.04	+ .03	47.0	+ 2.3	82	14	57	23	11	37	40	40	35	72	2.82	+ 1.5	6	9,662	nw.	40	se.	19	7	11	13	6.5	T.
Yankton	1,233	49	57	28.71	30.03	+ .02	48.8	− 1.7	90	14	59	25	29	39	50				2.29	+ 0.7	7	6,701	nw.	38	se.	2	6	6	19	7.3	T.
Northern Slope.							43.2	− 1.5										72	2.34	+ 1.4										5.5	
Havre	2,505	11	44	27.34	30.01	+ .03	41.2	− 2.4	75	1	51	16	22	31	41	37	34	80	1.18	+ 0.7	9	6,131	e.	44	w.	13	14	5	12	5.4	6.4
Miles City	2,371	26	48	27.48	30.06	+ .06	45.6	− 0.9	80	1	56	24	23	36	37	39	36	81	2.31	+ 1.4	7	4,603	w.	30	nw.	20	13	7	11	5.5	3.4
Helena	4,110	8	56	25.82	30.06	+ .03	41.6	− 2.4	72	1	50	22	18	33	32	37	33	76	1.88	+ 1.1	7	4,876	sw.	43	w.	20	8	8	15	6.2	5.0
Kalispell	2,962	8	34	26.94	30.03	+ .02	43.4	+ 0.9	68	9	53	24	22	34	33	38	34	78	1.53	+ 0.4	11	2,850	w.	21	sw.	1	11	8	12	5.4	
Rapid City	3,234	46	50	26.60	30.05	+ .04	46.3	− 0.3	83	12	57	23	23	36	45	39	32	66	2.09	+ 1.0	6	5,588	nw.	37	sw.	14	13	8	10	5.3	1.7
Cheyenne	6,088	56	64	24.01	30.03	+ .02	43.0	− 2.3	74	12	54	15	23	32	39	34	26	59	1.14	+ 0.4	5	7,512	nw.	35	s.	2	10	15	6	4.9	8.1
Lander	5,372	26	36	24.66	30.07	+ .03	40.8	− 1.3	75	1	53	13	23	28	43	34	28	64	4.57	+ 3.5	10	2,502	sw.	36	sw.	15	4	16	11	6.2	25.4
Sheridan	3,790	9	47	26.11	30.06	......	41.4	......	79	1	53	18	23	30	47	36	31	73	1.44	......	8	5,261	nw.	41	w.	12	8	7	16	5.8	10.4
Yellowstone Park	6,200	11	48	23.89	30.08	+ .06	37.6	− 3.9	67	11	48	12	22	28	35	31	27	71	3.00	+ 1.9	10	5,424	s.	42	s.	14	7	10	14	6.2	8.1
North Platte	2,821	11	51	27.08	30.03	+ .01	49.2	− 0.8	87	14	64	19	23	34	54	40	34	67	3.39	+ 2.2	3	6,379	se.	36	s.	19	16	12	3	4.1	
Middle Slope.							54.0	− 1.5										63	2.67	+ 1.1										4.1	
Denver	5,291	129	136	24.73	30.01	.00	48.8	− 2.2	80	15	61	21	23	36	38	38	27	52	1.90	+ 0.9	5	5,105	s.	31	n.	25	12	14	5	4.4	13.6
Leadville	10,248	7																													
Pueblo	4,685	80	86	25.29	29.99	.00	51.1	− 1.2	83	1	66	21	27	37	45	38	26	47	0.58	− 0.1	2	4,958	nw.	45	w.	16	20	9	2	2.9	2.6
Concordia	1,398	42	50	28.57	30.06	+ .03	54.0	− 1.4	86	14	64	30	24	44	33	47	42	73	1.74	− 0.3	5	6,688	s.	28	s.	15	8	15	8	5.1	T.
Dodge	2,509	44	54	27.41	30.02	+ .00	54.8	+ 0.1	90	15	67	26	23	42	36	45	38	65	1.17	− 0.2	4	8,873	se.	41	e.	19	19	10	2	3.2	
Wichita	1,358	90	120	28.64	30.07	+ .04	56.2	− 2.6	83	17	66	30	24	46	30	48	43	69	2.24	− 0.1	6	9,128	s.	34	sw.	16	11	14	6	4.8	T.
Oklahoma	1,214	10	47	28.77	30.05	+ .02	59.4	− 1.9	85	17	70	33	24	48	32	51	47	74	8.41	+ 6.6	9	12,351	s.	54	s.	19	15	8	8	4.4	
Southern Slope.							61.3	− 1.1										61	2.42	+ 0.6										3.0	
Abilene	1,738	45	54	28.23	30.04	+ .03	64.0	− 0.2	88	17	76	37	28	52	32	54	48	63	6.96	+ 4.6	7	6,560	s.	40	w.	19	15	12	4	3.6	
Amarillo	3,676	10	49	26.28	30.00	.00	56.6	+ 0.5	86	15	71	28	27	42	43	46	39	64	0.40	− 1.3	3	9,812	s.	48	sw.	19	27	4	0	2.9	1.0
Del Rio	944	8	57	29.03	30.01	+ .03	67.8	− 2.1	91	20	81	33	28	54	45				2.32	+ 0.8	3	6,645	se.	37	e.	7	19	11	1	3.0	
Roswell	3,578	9	57	26.38	30.01	+ .05	56.8	− 2.7	87	15	75	23	27	38	52	44	35	56	T.	− 1.5	0	4,691	s.	32	se.	18	21	9	1	2.4	
Southern Plateau.							56.2	− 3.7										40	0.37	− 0.5										1.6	
El Paso	3,762	110	133	26.20	29.95	+ .03	61.0	− 1.4	85	1	76	26	27	46	41	45	27	33	0.12	− 0.8	1	7,654	w.	50	nw.	18	28	3	0	0.8	
Santa Fe	7,013	33	39	23.28	30.00	+ .04	46.4	− 3.6	71	1	59	21	27	34	38	35	25	49	0.56	− 0.5	6	7,405	ne.	43	s.	18	23	7	1	2.3	3.6
Flagstaff	6,907	8	57	23.36	29.97	+ .05	41.2	− 3.5	74	10	56	15	21	26	45	31	20	51	0.99	− 0.9	3	6,819	sw.	58	sw.	2	22	4	5	2.4	6.0
Phoenix	1,108	50	56	28.77	29.92	+ .04	66.8	− 3.4	98	9	82	41	21	52	41	49	30	32	0.52	+ 0.2	2	3,081	e.	26	sw.	2	27	3	1	1.3	
Yuma	141	9	58	29.77	29.92	+ .05	68.2	− 4.2	104	10	86	38	19	51	46	51	36	37	T.	− 0.2	0	5,036	n.	35	w.	2	29	2	0	0.5	
Independence	3,910	11	42	26.00	29.99	+ .04	53.4	− 5.9	83	10	69	25	22	38	39	41	28	41	0.03	− 0.7	1	4,894	se.	36	nw.	2	25	3	3	2.1	
Middle Plateau.							46.4	− 3.8										53	1.45	+ 0.5										3.9	
Reno	4,532	56	63	25.50	30.04	+ .05	47.8	− 1.9	79	9	62	20	22	34	40	37	26	48	0.28	− 0.1	3	3,976	w.	40	w.	14	19	5	7	3.4	T.
Tonopah	6,089	12	20	24.08	30.05	......	46.9	− 1.5	72	10	56	21	21	38	27	36	22	39	0.06	− 0.8	1	7,529	se.	46	nw.	2	18	9	4	3.1	1.0
Winnemucca	4,344	18	56	25.66	30.08	+ .03	45.8	− 2.8	81	8	62	16	21	30	48	37	29	61	0.90	+ 0.4	6	4,616	ne.	42	sw.	14	18	6	7	3.5	0.8
Modena	5,479	10	43	24.64	30.03	+ .07	43.0	− 7.1	76	9	57	18	23	29	41	34	25	57	1.76	+ 0.9	8	7,612	w.	56	sw.	15	15	10	6	4.0	10.0
Salt Lake City	4,366	105	110	25.63	30.02	+ .01	48.2	− 4.0	76	11	58	28	23	39	31	40	33	60	2.07	+ 0.7	7	4,243	se.	40	nw.	15	8	11	12	5.9	0.1
Durango	6,546	18	56	23.67	30.00	+ .03	44.1	− 4.8	77	9	59	15	23	29	42	33	23	54	1.65	− 0.1	8	4,586	nw.	36	s.	18	17	9	5	3.6	11.8
Grand Junction	4,608	48	51	25.41	30.00	+ .01	48.8	− 4.5	78	10	61	26	23	37	38	38	27	51	3.43	+ 2.3	7	3,588	se.	36	s.	16	20	5	6	3.8	1.0
Northern Plateau.							48.9	− 0.5										65	1.61	+ 0.4										6.0	
Baker City	3,471	48	58	26.47	30.08	.00	45.8	+ 0.3	76	9	56	22	22	35	35	39	33	64	0.57	− 0.3	9	5,000	s.	32	s.	14	8	17	6	4.7	0.1
Boise	2,739	78	86	27.21	30.09	+ .03	49.6	− 0.7	79	8	60	27	22	39	36	41	34	60	1.33	0.0	9	3,596	nw.	38	nw.	1	6	9	16	6.5	T.
Lewiston	757	10	51	29.24	30.06	− .01	51.2	− 0.6	80	9	61	30	22	41	38				1.33	+ 0.1	12	3,045	e.	46	w.	1	2	10	19	7.2	
Pocatello	4,477	46	54	25.51	30.06	− .02	46.0	− 2.0	76	9	56	22	22	36	36	38	31	62	2.03	+ 1.0	7	6,160	se.	37	sw.	1	12	13	6	4.6	0.2
Spokane	1,929	101	110	27.99	30.06	.00	47.8	+ 0.5	77	9	57	26	22	39	35	42	37	70	2.30	+ 0.8	10	3,870	ne.	22	sw.	13	2	13	16	7.4	
Walla Walla	1,000	71	79	28.98	30.06	− .01	53.0	− 0.7	84	9	62	31	22	44	30	46	40	67	2.11	+ 0.6	7	4,042	s.	30	sw.	14	8	12	11	5.5	
N. Pac. Coast Reg.							50.5	− 0.6										82	4.31	+ 0.3										6.5	
Blaine	57	4																													
North Head	211	11	56	29.82	30.05	.00	51.8	− 1.1	79	7	56	42	21	48	23	49	46	86	3.45	− 0.5	15	11,006	se.	66	se.	12	9	8	14	6.2	
Port Crescent	259	12	29	29.78	30.06	+ .04	46.8	− 0.6	69	10	54	29	21	40	32				3.40	− 0.1	15	3,557	nw.	16	sw.	12	6	12	13	6.5	
Seattle	123	185	224	29.94	30.07	+ .02	50.8	0.0	72	8	57	38	21	45	28	48	45	82	2.34	− 0.5	14	5,307	se.	31	s.	13	3	10	18	7.3	

TABLE I.—*Climatological data for U. S. Weather Bureau stations, October, 1908*—Continued.

Stations.	Elevation of instruments. Barometer above sea level, feet.	Thermometers above ground.	Anemometer above ground.	Pressure, in inches. Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hrs.	Departure from normal.	Temperature of the air, in degrees Fahrenheit. Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation, in inches. Total.	Departure from normal.	Days with .01, or more.	Wind. Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness during daylight, tenths.	Total snowfall.
N. P. Coast Reg—Cont.																															
Tacoma	213	113	120	29.82	30.05	+ .01	50.2	− 0.4	75	8	57	33	23	43	31	47	44	81	3.65	+ 0.2	13	3,338	sw.	26	sw.	1	4	8	19	7.4	
Tatoosh Island	86	7	57	29.93	30.03	+ .02	48.8	− 1.1	63	8	52	40	31	45	13	46	44	85	6.90	− 1.1	15	12,546	ne.	54	s.	29	6	7	18	6.7	
Portland, Oreg.	153	68	106	29.90	30.06	.00	52.9	− 0.4	79	7	60	35	21	45	30	49	45	78	5.17	+ 1.5	15	4,119	nw.	25	sw.	14	9	9	13	5.8	
Roseburg	510	9	57	29.53	30.08	.00	52.0	− 0.8	85	7	62	34	21	42	49	48	45	81	5.29	+ 2.7	14	1,872	nw.	20	n.	20	10	9	12	5.4	
Mid. Pac. Coast Reg.							57.4	− 1.2										68	1.24	− 0.1										4.0	
Eureka	62	62	80	30.01	30.08	+ .02	52.3	− 0.8	72	7	59	36	21	46	24	49	47	86	5.09	+ 2.4	11	4,720	n.	39	n.	2	11	7	13	5.5	
Mount Tamalpais	2,375	11	18	27.57	30.04	+ .03	55.4		80	7	61	38	20	49	23	46	38	60	1.68	+ 0.4	6	13,960	nw.	74	nw.	1	20	7	4	2.8	
Point Reyes Light	490	7	18	29.48	29.99		51.4		79	25	60	44	21	49	28				0.61		7	13,646	nw.	90	nw.	1	13	7	11	4.9	
Red Bluff	332	50	56																												
Sacramento	69	106	117	29.93	30.00	+ .01	60.7	− 1.5	89	7	73	41	22	48	37	52	43	56	0.26	− 0.8	3	6,104	s.	34	nw.	2	23	5	3	2.3	
San Francisco	155	200	204	29.86	30.03	+ .02	58.8	+ 0.4	82	25	66	47	28	51	32	52	46	71	0.61	− 0.7	5	5,417	w.	32	ne.	18	16	7	8	3.9	
San Jose	141	78	88	29.89	30.04		57.6	− 2.7	90	7	72	33	22	43	44				0.19	− 1.1	3	4,009	nw.	34	nw.	2	20	8	3	2.8	
Southeast Farallon	30	9	17	30.01	30.04		53.5		75	25	57	46	27	50	21				0.25	− 1.0	5	9,997	nw.	58	nw.	1	12	4	15	5.5	
S. Pac. Coast Reg.							61.7	− 0.6										61	0.27	− 0.6										2.1	
Fresno	330	67	70	29.64	30.00	+ .04	62.0	− 2.7	94	8	77	36	21	47	39	50	38	51	0.02	− 0.7	1	3,179	nw.	18	nw.	15	24	6	1	1.7	
Los Angeles	338	159	191	29.61	29.97	+ .02	64.6	+ 2.3	88	7	75	46	31	54	34	52	43	56	0.25	− 0.5	2	4,834	ne.	21	nw.	20	22	6	3	2.4	
San Diego	87	94	102	29.88	29.97	+ .02	61.6	− 1.4	80	9	68	48	19	55	23	54	48	66	0.15	− 0.3	3	4,498	nw.	22	nw.	5	26	3	2	1.7	
San Luis Obispo	201	47	54	29.81	30.03	+ .04	58.5	− 0.7	90	6	72	38	19	45	43	50	45	71	0.59	− 0.7	4	3,297	nw.	18	w.	2	22	6	3	2.7	
West Indies.																															
Grand Turk	11	6	20																												
San Juan	82	48	90	29.82	29.91	+ .01	80.4		92	5	87	69	17	74	18	75	73	81	3.64	− 2.5	10	6,188	se.	42	se.	17	10	14	7	4.9	
Panama.																															
Christobal	17	5	60	29.83	29.85		78.7		90	6	85	70	6	73	16	74	74	90	10.96		22	5,054	se.	31	se.	17	3	17	11	6.8	
Bas Obispo	172	4	30	29.68	29.86		77.4		87	21	84	66	26	70	19	73	73	94	8.30		24	3,300	se.	25	se.	17	0	4	27	8.2	
Ancon	92	6	69	29.76	29.85		78.9		92	21	85	69	26	72	21	74	73	88	8.79		20	5,246	nw.	37	s.	16	0	15	16	7.3	
Alhajuela																															
Bohio																															
Gatun																															

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for storms in which the rate of fall equaled or exceeded 0.25 in any 5 minutes, or 0.80 inch in 1 hour, during October, 1908, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	To—	Total amount of precipitation.	Excessive rate. Began—	Ended—	Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated. 5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex	6	7:05 p. m.	8:55 p. m.	1.30	7:12 p. m.	7:59 p. m.	0.06	0.08	0.26	0.32	0.43	0.63	0.84	0.98	1.05	1.11	1.15				
Do	22	12:01 a. m.	6:30 a. m.	4.65	12:17 a. m.	2:11 a. m.	0.07	0.06	0.16	0.41	0.71	0.80	0.89	1.05	1.35	1.70	1.92	2.27	2.50	3.29	3.94
Albany, N. Y	26			0.72														0.25			
Alpena, Mich	24			0.86														0.27			
Amarillo, Tex	4			0.15														0.15			
Anniston, Ala	9			1.34														0.59			
Asheville, N. C	9			1.74														0.56			
Atlanta, Ga	9	3:00 p. m.	5:15 p. m.	0.72	3:20 p. m.	3:40 p. m.	0.05	0.10†	0.30†	0.55†	0.61†										
Atlantic City, N. J	29–30	12:25 p. m.	D. N.	2.71	6:03 p. m.	6:31 p. m.	0.39	0.07	0.22	0.37	0.48	0.55									
Augusta, Ga	28			1.27														0.32			
Baker City, Oreg	1			0.16														0.13			
Baltimore, Md	26			0.53														0.45			
Bentonville, Ark	20			0.55														0.34			
Binghamton, N. Y	26	9:45 a. m.	12:25 p. m.	0.79	11:07 a. m.	11:42 a. m.	0.02	0.09	0.18	0.38	0.53	0.59	0.62	0.67							
Birmingham, Ala	8			0.58														0.14			
Bismarck, N. Dak	19			1.15														*			
Block Island, R. I	1			2.41														0.72			
Boise, Idaho	14			0.48														0.17			
Boston, Mass	26			1.46														0.31			
Buffalo, N. Y	10			0.11														0.09			
Burlington, Vt	11			0.52														0.33			
Cairo, Ill	24			0.02														0.02			
Canton, N. Y	11			0.47														0.21			
Charles City, Iowa	5			0.36														0.28			
Charleston, S. C	28			0.72														0.30			
Charlotte, N. C	22–23	D. N.	4:35 p. m.	2.02	3:47 p. m.	3:58 p. m.	1.64	0.10	0.27	0.35											
Chattanooga, Tenn	9			1.16														0.27			
Cheyenne, Wyo	17–18			0.60														*			
Chicago, Ill	8			0.26														0.10			
Cincinnatti, Ohio	23			0.27														0.07			
Cleveland, Ohio	28			0.61														0.18			
Columbia, Mo	23–24			0.83														0.37			
Columbia, S. C	28			1.25														0.29			
Columbus, Ohio	10			0.46														0.10			
Concord, N. H	11			0.49														0.29			
Concordia, Kans	19			0.81														0.42			
Corpus Christi, Tex	27			0.22														0.07			
Davenport, Iowa	24			0.58														0.17			
Del Rio, Tex	7	1:10 a. m.	5:10 a. m.	1.86	1:47 a. m.	2:42 a. m.	0.02	0.11	0.31	0.39	0.42	0.46	0.57	0.85	1.04	1.30	1.50	1.61			
Denver, Colo	17–18			1.24														*			
Des Moines, Iowa	21			1.28														0.23			
Detroit, Mich	24			0.89														0.26			
Devils Lake, N. Dak	16			0.34														0.13			
Dodge City, Kans	19	D. N.	11:30 a. m.	0.82	8:20 a. m.	8:42 a. m.	0.05	0.14	0.34	0.41	0.46	0.50									
Dubuque, Iowa	24			0.53														0.22			
Duluth, Minn	20			0.73														0.24			
Durango, Colo	18–19			0.56														*			
Eastport, Me	1–2			1.85														0.54			
Elkins, W. Va	28			0.28														0.10			
El Paso, Tex	26			0.12														0.05			
Erie, Pa	8			0.62														0.18			
Escanaba, Mich	24			0.60														0.11			
Eureka, Cal	13–14			3.61														0.58			
Evansville, Ind	7			0.28														0.26†			

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Flagstaff, Ariz	17–18			0.68														*			
Fort Smith, Ark	20			1.20														0.43			
Fort Worth, Tex	22	7:30 a. m.	2:20 p. m.	2.14	9:21 a. m.	9:56 a. m.	0.45	0.16	0.32	0.43	0.63	1.03	1.22	1.32							
Fresno, Cal	15			0.02														0.02			
Galveston, Tex	26–27			0.17														0.09			
Grand Haven, Mich	27			0.34														0.13			
Grand Junction, Colo	17–18			2.50														0.21			
Grand Rapids, Mich	24			0.38														0.18			
Green Bay, Wis	24			0.35														0.08			
Hannibal, Mo	24			0.25														0.14			
Harrisburg, Pa	10–11	4:06 p. m.	D. N.	1.50	12:11 a. m.	12:58 a. m.	0.11	0.15	0.26	0.40	0.43	0.52	0.66	0.85	0.97	1.10					
Do	26	11:31 p. m.	11:85 p. m.	0.53	11:34 p. m.	11:41 p. m.	0.01	0.43	0.52												
Hartford, Conn	26			0.38														0.20			
Hatteras, N. C	8	3:10 p. m.	11:25 p. m.	2.74	8:20 p. m.	9:40 p. m.	1.03	0.07	0.13	0.20	0.23	0.27	0.35	0.41	0.48	0.62	0.73	1.11	1.51		
Do	10	6:05 a. m.	7:35 a. m.	1.51	6:22 a. m.	6:50 a. m.	0.19	0.10	0.31	0.47	0.88	1.18	1.30								
Havre, Mont	19–20			0.68														*			
Helena, Mont	2			1.04														0.12			
Houghton, Mich	7			0.38														0.14			
Huron, S. Dak	4			1.44														0.48			
Independence, Cal	17			0.03														0.03			
Indianapolis, Ind	7			0.12														0.11			
Iola, Kans	21	10:45 a. m.	12:35 p. m.	0.64	11:31 a. m.	11:51 a. m.	0.04	0.18	0.23	0.24	0.45										
Do	21–22	5:34 p. m.	2:30 a. m.	2.47	6:59 p. m.	7:48 p. m.	0.21	0.27	0.46	0.63	0.67	0.69	0.69	0.70	0.79	0.96	1.01				
Jacksonville, Fla	8–9	5:35 p. m.	D. N.	1.69	5:51 p. m.	6:34 p. m.	0.05	0.09	0.17	0.41	0.68	0.94	1.09	1.15	1.20	1.25					
Do	11–12	2:53 p. m.	4:30 a. m.	5.30	11:48 p. m.	12:33 a. m.	2.73	0.06	0.15	0.21	0.41	0.61	0.92	1.25	1.58	1.65					
Do	12	2:20 p. m.	10:30 p. m.	3.44	3:14 p. m.	4:04 p. m.	0.07	0.26	0.42	0.59	0.74	0.91	1.03	1.10	1.15	1.22	1.31				
					4:04 p. m.	4:54 p. m.	.....	1.36	1.46	1.56	1.65	1.73	1.88	2.10	2.32	2.48	2.62	2.73	3.01		
Jupiter, Fla	27–28	9:30 p. m.	8:00 a. m.	5.59	12:05 a. m.	2:05 a. m.	0.32	0.31	0.62	0.88	1.35	1.63	2.10	2.64	3.17	3.40	3.66	3.83	4.15	4.41	4.59
Kalispell, Mont	11–12			0.52														0.25			
Kansas City, Mo	21–22	4:15 p. m.	D. N.	4.11	5:56 p. m.	6:46 p. m.	0.64	0.13	0.26	0.35	0.36	0.37	0.37	0.40	0.50	0.61	0.68				
					6:46 p. m.	7:36 p. m.	.....	0.68	0.77	0.95	1.09	1.18	1.28	1.37	1.43	1.47	1.52				
					7:36 p. m.	8:14 p. m.	.....	1.59	1.63	1.74	1.85	1.92	1.96	2.01	2.05						
Keokuk, Iowa	24–25			0.36														0.20			
Key West, Fla	3	12:15 a. m.	1:35 a. m.	0.63	12:27 a. m.	12:57 a. m.	0.01	0.14	0.25	0.37	0.47	0.53	0.60								
Do	3	4:20 a. m.	5:45 p. m.	2.86	10:17 a. m.	10:55 a. m.	0.34	0.12	0.35	0.58	0.79	1.03	1.17	1.25	1.36						
Knoxville, Tenn	9	6:00 a. m.	7:30 p. m.	1.22	5:05 p. m.	5:33 p. m.	0.43	0.15	0.34	0.52	0.61	0.66	0.70								
La Crosse, Wis	21			0.60														0.50			
Lander, Wyo	2–3			2.04														*			
La Salle, Ill	24			0.11														0.04			
Lewiston, Idaho	19			0.29														0.13			
Lexington, Ky	9–10			0.25														0.12			
Lincoln, Nebr	5			0.89														0.25			
Little Rock, Ark	23			0.34														0.17			
Los Angeles, Cal	15			0.15														0.05			
Louisville, Ky	23			0.04														0.02			
Lynchburg, Va	23			1.00														0.22			
Macon, Ga	27–28			1.78														0.31			
Madison, Wis	6			0.09														0.09			
Marquette, Mich	1			0.38														*			
Memphis, Tenn	23			0.05														0.04			
Meridian, Miss	8–9			0.38														0.12			
Milwaukee, Wis	23–24			0.74														0.24			
Minneapolis, Minn	21			0.61														0.21			
Mobile, Ala	27			0.25														0.11			
Modena, Utah	15–16			1.24														*			
Montgomery, Ala	8			1.56														0.48			
Moorhead, Minn	24–25			0.57														0.11			
Mount Tamalpais, Cal	14–15			1.20														0.29			
Mount Weather, Va	10–11	12:40 p. m.	D. N.	1.24	10:47 p. m.	11:21 p. m.	0.51	0.20	0.29	0.31	0.36	0.47	0.49	0.56							
Nantucket, Mass	30			0.84														0.70			
Nashville, Tenn	9			0.35														0.09			
New Haven, Conn	29–30			0.83														0.19			
New Orleans, La	27			0.61														0.16			
New York, N. Y	26	4:48 p. m.	6:34 p. m.	0.65	5:12 p. m.	5:37 p. m.	0.05	0.21	0.31	0.40	0.50	0.55									
Norfolk, Va	24			0.73														0.39			
Northfield, Vt	11			0.61														0.25			
North Head, Wash	14			0.52														0.20			
North Platte, Nebr	18–19	D. N.	2:45 p. m.	3.25	7:52 a. m.	9:01 a. m.	0.48	0.05	0.12	0.30	0.54	0.80	1.03	1.11	1.20	1.26	1.32	1.50	1.63		
Oklahoma, Okla	20–21	6:10 p. m.	D. N.	1.94	12:56 a. m.	1:41 a. m.	0.73	0.05	0.28	0.41	0.69	0.71	0.79	0.97	1.07	1.18					
Do	21–22	5:45 p. m.	D. N.	1.97	6:24 p. m.	7:54 p. m.	0.10	0.13	0.32	0.36	0.37	0.37	0.37	0.40	0.57	0.59	0.70	0.84	1.40	1.73	
Do	22–23	D. N.	D. N.	3.24	12:47 p. m.	1:12 p. m.	1.75	0.08	0.26	0.41	0.52	0.60									
Omaha, Nebr	19			1.00														0.44			
Oswego, N. Y	24–25			0.82														0.27			
Palestine, Tex	22	4:40 p. m.	7:08 p. m.	1.02	4:44 p. m.	5:19 p. m.	0.02	0.18	0.33	0.46	0.53	0.60	0.62	0.72							
Parkersburg, W. Va	10			0.60														0.30			
Pensacola, Fla	28			0.38														0.27			
Peoria, Ill	24			0.29														0.11			
Philadelphia, Pa	29			1.07														0.30			
Phoenix, Ariz	17			0.20														0.16			
Pierre, S. Dak	19			1.81														0.62			
Pittsburg, Pa	10			0.34														0.16			
Pocatello, Idaho	15			0.67														0.22			
Point Reyes Light, Cal	30			0.12														0.11			
Port Huron, Mich	24			0.51														0.15			
Portland, Me	27			0.73														0.39			
Portland, Oreg	14			1.65														0.42			
Providence, R. I	1			0.84														0.29			
Pueblo, Colo	18			0.46														0.11			
Raleigh, N. C	10			0.44														0.38			
Rapid City, S. Dak	19			0.99														*			
Red Bluff, Cal	29			0.11																	
Reno, Nev	14			0.15														0.10			
Richmond, Va	29			1.71														0.32			
Rochester, N. Y	28			0.80														0.20			
Roseburg, Oreg	14–15			2.12														0.30			
Roswell, N. Mex	22			T.														T.			
Sacramento, Cal	14			0.12														0.07			
St. Louis, Mo	24			0.20														*			
St. Paul, Minn	20			0.24														0.14			
Salt Lake City, Utah	15			0.84														0.26			
San Antonio, Tex	22	4:30 p. m.	6:15 p. m.	0.52	4:34 p. m.	4:51 p. m.	0.01	0.09	0.20	0.42	0.49										
San Diego, Cal	15			0.13														0.09			
Sand Key, Fla	3	9:40 a. m.	4:55 p. m.	1.52	9:47 a. m.	10:20 a. m.	0.03	0.11	0.30	0.43	0.51	0.55	0.62	0.67							
Sandusky, Ohio	23			0.44														0.30			

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, etc.*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
San Francisco, Cal	15			0.13														0.11			
San Jose, Cal	14			0.13														0.10			
San Luis Obispo, Cal	15			0.47														0.69			
Santa Fe, N. Mex	22			0.27														*			
Sault Sainte Marie, Mich	24			0.80														0.24			
Savannah, Ga	8			0.53														0.47			
Scranton, Pa	26	8:10 a. m.	11:33 a. m.	0.53	10:36 a. m.	10:51 a. m.	0.05	0.18	0.31	0.37											
Seattle, Wash	1			0.25														0.23			
Sheridan, Wyo	3			1.16														*			
Shreveport, La	8‡			T.														T.			
Sioux City, Iowa	19			0.84														0.52			
Southeast Farallon, Cal	14			0.13														0.05			
Spokane, Wash	1			0.33														0.25			
Springfield, Ill	26			0.14														0.03			
Springfield, Mo	23			0.79														0.33			
Syracuse, N. Y	10-11			0.87														0.27			
Tacoma, Wash	13			0.41														0.13			
Tampa, Fla	27			0.62														0.22			
Tatoosh Island, Wash	18			0.86														0.26			
Taylor, Tex	22			0.77														0.73			
Thomasville, Ga	27	2:01 p. m.	3:05 p. m.	0.75	2:02 p. m.	2:20 p. m.	0.01	0.16	0.22	0.48	0.55										
Toledo, Ohio	24			0.42														0.24			
Tonopah, Nev	17			0.06														*			
Topeka, Kans	19			0.58														0.35			
Vicksburg, Miss	27			0.03														0.02			
Walla Walla, Wash	13			0.60														0.12			
Washington, D. C	29			0.95														0.28			
Wichita, Kans	19			0.67														0.40			
Williston, N. Dak	19			0.82														0.18			
Wilmington, N. C	28	1:50 p. m.	7:10 p. m.	1.48	4:07 p. m.	5:27 p. m.	0.24	0.19	0.23	0.25	0.26	0.31	0.42	0.56	0.63	0.64	0.66	0.70	1.05		
Winnemucca, Nev	2-3			0.25														*			
Wytheville, Va	10			1.81														0.60			
Yankton, S. Dak	19			0.52														0.32			
Yellowstone Park, Wyo	15			1.23														0.24			
Yuma, Ariz	17			T.														T.			

*Partly estimated. †Estimated. ‡And other dates.

TABLE III.—*Data furnished by the Canadian Meteorological Service, October, 1908.*

Stations.	Pressure. Actual, reduced to mean of 24 hours.	Pressure. Sea level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature. Mean.	Temperature. Departure from normal.	Temperature. Mean maximum.	Temperature. Mean minimum.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Ins.	*Ins.*	*Ins.*	°	°	°	°	*Ins.*	*Ins.*	*Ins.*
St. Johns, N. F.										
Sydney, C. B. I.	30.03	30.07	+.11	50.5	+4.0	60.3	40.7	3.22	−1.47	....
Halifax, N. S.	29.99	30.10	+.10	50.4	+3.2	60.7	40.0	3.70	−1.85	....
Grand Manan, N. B.	30.03	30.08	+.08	51.9	+5.0	58.9	44.9	4.90	+0.19	T.
Yarmouth, N. S.	30.05	30.12	+.10	49.0	+1.4	57.6	40.4	5.28	+0.58	0.2
Charlottetown, P. E. I.	30.02	30.06	+.10	50.1	+3.6	57.4	42.8	2.08	−2.82	....
Chatham, N. B.	30.02	30.04	+.08	49.0	+6.0	59.0	39.0	5.67	+1.81	1.0
Father Point, Que.	30.03	30.05	+.10	43.8	+4.0	49.9	37.7	3.55	+0.65	1.8
Quebec, Que.	29.78	30.11	+.11	46.4	+4.0	54.2	38.6	2.18	−0.97	T.
Montreal, Que.	29.92	30.13	+.12	50.1	+5.3	57.1	43.1	1.49	−1.64	T.
Rockliffe, Ont.	29.52	30.13	+.12	44.3	+1.5	53.4	35.2	1.14	−1.29	....
Ottawa, Ont.	29.89	....	....	48.9	+5.1	58.6	39.1	2.40	−0.15	....
Kingston, Ont.	29.85	30.16	+.13	51.7	+4.7	59.6	43.8	2.17	−0.56	T.
Toronto, Ont.	29.78	30.16	+.12	51.4	+4.8	61.2	41.6	1.02	−1.34	T.
White River, Ont.										
Port Stanley, Ont.	29.51	30.15	+.10	49.9	+2.1	58.8	40.9	1.53	−1.45	T.
Southampton, Ont.	29.43	....	....	50.6	+4.5	59.9	41.2	1.07	−2.10	0.3
Parry Sound, Ont.	29.45	30.15	+.14	49.4	+5.5	59.4	39.4	0.57	−3.35	....
Port Arthur, Ont.	29.35	30.07	+.09	44.7	+4.8	51.8	37.5	1.00	−1.56	....
Winnipeg, Man.	29.19	30.04	+.06	43.3	+4.2	51.2	35.3	2.21	+0.51	....
Minnedosa, Man.	28.15	30.00	+.03	40.0	+2.2	50.2	29.7	0.48	−0.72	0.7
Qu' Appelle, Assin.	27.64	29.91	−.06	38.0	−1.4	47.5	28.4	1.61	+0.51	....
Medicine Hat, Alberta	27.70	30.00	+.03	42.7	−2.1	52.0	33.4	1.22	+0.64	5.5
Swift Current, Sask.	27.40	30.01	+.04	37.6	−4.5	45.2	30.0	2.58	+1.70	13.8
Calgary, Alberta	26.41	29.97	+.02	40.4	+0.3	51.1	29.8	0.55	+0.07	2.3
Banff, Alberta	25.37	30.01	+.06	36.4	−2.9	46.2	26.7	1.87	+0.85	12.7
Edmonton, Alberta	27.64	29.96	+.03	38.5	−2.6	49.4	27.6	1.48	+0.78	9.5
Prince Albert, Sask.	28.40	29.98	+.01	37.1	0.0	46.3	27.9	1.63	+0.80	....
Battleford, Sask.	28.21	29.98	+.01	37.0	−2.6	46.4	27.6	0.13	−0.32	....
Kamloops, B. C.	28.74	29.97	+.01	46.3	−0.7	54.9	37.7	0.65	+0.04	....
Victoria, B. C.	29.93	30.03	+.02	49.3	+0.1	55.4	43.2	2.33	−0.04	....
Barkerville, B. C.	25.63	29.96	+.02	37.0	−2.7	45.8	28.2	5.25	+2.55	....
Hamilton, Bermuda	29.86	30.02	.00	74.1	+1.1	77.8	70.4	9.62	+2.91	....
Dawson, Yukon	....	....	....	....	....	....	....	....	....	....

TABLE IV.—*Heights of rivers referred to zeros of gages, October, 1908.*

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water. Height.	Highest water. Date.	Lowest water. Height.	Lowest water. Date.	Mean stage.	Monthly range.
	Miles.	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Republican River.								
Clay Center, Kans.	42	18	8.9	26	5.7	3-11	6.2	3.2
Smoky Hill-Kansas River.								
Abilene, Kans.	254	22	1.7	28, 31	1.0	23, 25, 26	1.4	0.7
Manhattan, Kans.	160	18	3.9	27, 28	2.6	13, 14, 17-20	2.9	1.3
Topeka, Kans.	87	21	7.0	29	5.7	7	6.0	1.3
Missouri River.								
Townsend, Mont.	2,504	11	5.6	18, 19	4.8	1	5.1	0.8
Fort Benton, Mont.	2,285	12	3.0	22-25, 29-31	1.5	1, 2	2.3	1.5
Wolfpoint, Mont.	1,952	17	0.2	27-29	−1.9	11	−1.0	2.1
Bismarck, N. Dak.	1,309	14	2.4	16-18, 26	1.7	5, 6	2.2	0.7
Pierre, S. Dak.	1,114	14	3.4	24	1.1	1, 2, 6, 7	1.9	2.3
Sioux City, Iowa	784	17	7.5	24	4.3	5	5.2	3.2
Blair, Nebr.	705	15	7.5	24	5.2	4-19	5.7	2.3
Omaha, Nebr.	669	18	10.8	25	8.2	6-17	8.7	2.6
St. Joseph, Mo.	481	10	4.8	26	0.9	6, 17-20	1.8	3.9
Kansas City, Mo.	388	21	11.8	27	6.4	17-20	7.7	5.4
Glasgow, Mo.	231	21	12.9	29	7.5	13	8.7	5.4
Boonville, Mo.	199	20	13.1	29	7.7	23	8.9	5.4
Hermann, Mo.	103	24	12.5	30	5.4	21-23	6.7	7.1
Minnesota River.								
Mankato, Minn.	127	18	2.9	31	2.3	17-20	2.5	0.6
St. Croix River.								
Stillwater, Minn.	23	11	3.5	31	2.6	23, 24	3.0	0.9
Illinois River.								
La Salle, Ill.	197	18	11.6	8, 9, 18, 25-31	11.4	2-6, 13-16, 19	11.5	0.2
Peoria, Ill.	135	14	8.0	28-30	7.5	16	7.8	0.5
Conemaugh River.								
Johnstown, Pa.	64	7	0.5	1	0.3	2, 15-31	0.3	0.2
Allegheny River.								
Warren, Pa.	177	14	−0.5	1-8	−0.9	27-30	−0.7	0.4
Parker, Pa.	73	20	−0.2	2-7	−0.5	1, 21-29	−0.4	0.3
Freeport, Pa.	29	20	1.1	31	0.6	1, 20-23	0.8	0.5
Springdale, Pa.	17	27	7.6	6-8	5.8	1	7.3	1.8
Youghiogheny River.								
Confluence, Pa.	59	10	−0.5	1-4	−0.7	17-26, 29-31	−0.6	0.2
West Newton, Pa.	15	23	0.0	1	−0.2	4-31	−0.2	0.2
Monongahela River.								
Fairmont, W. Va.	119	25	11.3	1	9.9	29-31	10.3	1.4
Greensboro, Pa.	81	18	6.3	15	5.2	14	5.7	1.1
Lock No. 4, Pa.	40	28	9.0	1-10, 29	8.9	11-28, 30, 31	8.9	0.1
Muskingum River.								
Zanesville, Ohio	70	25	7.7	*	7.5	4	7.7	0.2
Little Kanawha River.								
Creston, W. Va.	38	20	−1.2	12-14	−1.5	1-10, 21-31	1.4	0.3
New-Great Kanawha River.								
Hinton, W. Va.	153	14	6.1	25	1.2	4-9, 23	2.1	4.9
Charleston, W. Va.	58	30	7.7	13	4.3	29	6.8	3.4
Scioto River.								
Columbus, Ohio	110	17	1.6	1-31	1.6	1-31	1.6	0.0
Licking River.								
Falmouth, Ky.	30	25	1.0	1, 2, 31	0.0	20-23	0.5	1.0
Kentucky River.								
Beattyville, Ky.	254	30	1.8	30	−0.4	2-7	0.7	2.2
Frankfort, Ky.	65	31	4.7	1	3.3	30, 31	3.9	1.4
Wabash River.								
Mount Carmel, Ill.	75	15	1.1	1-6	0.8	14-31	0.9	0.3
Cumberland River.								
Burnside, Ky.	518	50	−0.6	16-21	−1.0	6-9	−0.8	0.4
Celina, Tenn.	383	45	0.6	1, 2, 14-17	0.3	8, 9	0.5	0.3
Carthage, Tenn.	308	40	0.3	1-4	−0.1	11-13	0.1	0.4
Nashville, Tenn.	193	40	7.4	7	6.5	9	6.8	0.9
Clarksville, Tenn.	126	43	1.8	10	0.0	7, 12-31	0.4	1.8
Clinch River.								
Speers Ferry, Va.	156	20	1.0	25, 30	−0.2	8	0.4	1.2
Clinton, Tenn.	52	25	3.8	30, 31	2.0	5-8	2.9	1.8
South Fork Holston River.								
Bluff City, Tenn.	35	12	2.3	30, 31	0.2	3-9, 19-23	0.5	2.1
Holston River.								
Rogersville, Tenn.	103	14	3.6	25, 31	1.4	5-9, 18-22	1.8	2.2
French Broad River.								
Asheville, N. C.	144	4	3.6	30	−0.4	8	0.5	4.0
Dandridge, Tenn.	46	12	7.5	24	0.5	7-9	1.7	7.0
Tennessee River.								
Knoxville, Tenn.	635	12	7.0	30	0.3	9	1.8	6.7
Loudon, Tenn.	590	25	5.7	31	0.7	5-9	1.6	5.0
Kingston, Tenn.	556	25	5.0	31	1.2	1-9	2.2	3.8
Chattanooga, Tenn.	452	33	5.0	28	1.3	7, 8	2.1	3.7
Bridgeport, Ala.	402	24	3.6	28	0.3	1, 2, 8	1.0	3.3
Guntersville, Ala.	349	31	6.0	29	1.5	*	2.3	4.5
Florence, Ala.	255	16	2.5	30	−0.1	2, 4-7, 27, 28	0.3	2.6
Riverton, Ala. (a)	225	32	11.2	31	7.4	28	8.1	3.8
Johnsonville, Tenn.	95	21	2.2	19, 20	0.7	30	1.2	1.5
Ohio River.								
Pittsburg, Pa.	966	22	5.9	*	5.6	4, 10, 11	5.8	0.3
Coraopolis, Pa.	956	25	9.6	16, 19	7.8	9	8.9	1.8
Beaver Dam, Pa.	937	27	1.5	8, 30, 31	0.8	4	1.2	0.7
Wheeling, W. Va.	875	36	0.6	26-29	0.0	1-9	0.3	0.6
Parkersburg, W. Va.	785	36	0.3	30, 31	−0.3	7-10	0.0	0.6
Point Pleasant, W. Va.	703	39	4.8	27	0.2	2	1.1	4.6
Huntington, W. Va.	660	50	8.0	27	2.1	3	3.5	5.9
Catlettsburg, Ky.	651	50	6.2	28	2.3	22	3.1	3.9
Portsmouth, Ohio	612	50	7.0	28	1.4	4, 5	2.5	5.6
Maysville, Ky.	559	50	6.7	29	2.2	6	3.0	4.5
Cincinnati, Ohio	499	50	7.5	30	2.8	5-7	3.6	4.7
Madison, Ind.	413	46	5.6	31	2.5	8, 9	3.1	3.1
Louisville, Ky.	367	28	3.6	20	2.7	8-16	2.9	0.9
Evansville, Ind.	184	35	2.5	25	1.3	11-16	1.6	1.2
Mount Vernon, Ind.	148	35	2.3	26	1.1	16, 17	1.6	1.2
Paducah, Ky.	47	40	2.2	1, 2	1.2	31	1.5	1.0
Cairo, Ill.	1	45	6.9	31	4.3	17-19	4.9	2.6
Neosho River.								
Iola, Kans.	262	10	10.0	23	−2.8	19, 20	−0.2	12.8
Oswego, Kans.	184	20	21.0	26	0.1	18-20	4.6	20.9
Fort Gibson, Okla.	3	22	24.0	24	8.8	1-10	12.6	15.2
Canadian River.								
Calvin, Okla.	99	10	8.4	23	2.7	18, 19	4.1	5.7
Black River.								
Blackrock, Ark.	67	12	2.3	1-5	2.0	21-31	2.1	0.3
White River.								
Calicorock, Ark.	272	18	1.6	1	−0.4	20-25	−0.1	1.4
Batesville, Ark.	217	18	3.0	1	1.6	19-31	1.9	1.4
Clarendon, Ark.	75	30	11.8	3	7.2	28-31	8.6	4.6
Arkansas River.								
Wichita, Kans.	832	10	5.0	24, 25	−2.3	11, 14-22	−0.8	7.3
Tulsa, Okla.	551	16	15.7	23	2.2	20	5.1	13.5
Webbers Falls, Okla.	465	23	22.5	24	4.6	18-22	9.7	17.9
Fort Smith, Ark.	403	22	23.5	24	3.8	12-20	8.0	19.7
Dardanelle, Ark.	256	21	20.9	31	4.0	19-21	8.2	16.9
Little Rock, Ark.	176	23	21.5	26	3.4	23	7.8	18.1
Pine Bluff, Ark.	121	25	22.6	28	7.0	23, 24	10.6	15.6
Yazoo River.								
Greenwood, Miss.	175	38	2.5	1, 2	1.4	26-31	1.7	1.1
Yazoo City, Miss.	80	25	0.4	1	−2.2	31	−1.1	2.6
Ouachita River.								
Camden, Ark.	304	39	6.5	1	3.5	15, 16, 25-30	4.1	3.0
Monroe, La.	122	40	5.6	3	−1.2	30, 31	1.6	6.8
Red River.								
Arthur City, Tex.	688	27	18.7	25	6.4	14	9.9	12.3
Fulton, Ark.	515	28	24.0	28	8.8	17, 18, 24	12.8	15.2
Shreveport, La.	327	29	11.9	30	−0.5	21, 22	2.4	12.4
Mississippi River.								
Fort Ripley, Minn.	2,082	10	5.7	5	5.0	17-19	5.3	0.7

TABLE IV.—*Heights of rivers referred to zeros of gages*—Continued.

Stations.	Distance to mouth of river.	Flood stage on gage.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Mississippi River.—Cont'd.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
St. Paul, Minn.	1,954	14	4.0	30,31	3.0	19	3.7	1.0
Red Wing, Minn.	1,914	14	1.6	31	1.3	17,18	1.4	0.3
Reeds Landing, Minn.	1,884	12	1.5	7,8	1.0	2,19,20	1.2	0.5
La Crosse, Wis.	1,819	12	2.5	30,31	2.1	20,21	2.3	0.4
Prairie du Chien, Wis.	1,759	18	2.7	10–13, 27–31	2.3	21	2.5	0.4
Dubuque, Iowa	1,699	18	2.7	11–13, 29–31	2.4	18, 21–25	2.5	0.3
Clinton, Iowa	1,629	16	2.5	1, 12–15	2.1	20,21	2.3	0.4
Leclaire, Iowa	1,609	10	1.2	1	0.9	6–9, 20–25	1.0	0.3
Davenport, Iowa	1,593	15	2.4	1, 2, 12, 15, 29–31	2.0	25	2.2	0.4
Muscatine, Iowa	1,562	16	3.1	2	2.7	26	2.9	0.4
Galland, Iowa	1,472	8	1.1	4–8, 27–31	1.0	1–3, 9–26	1.0	0.1
Keokuk, Iowa	1,463	15	2.0	31	1.3	1–3, 22–24	1.4	0.7
Warsaw, Ill	1,458	18	5.2	31	4.1	22–25	4.4	1.1
Hannibal, Mo	1,402	13	3.1	31	2.0	25,26	2.3	1.1
Grafton, Ill	1,306	23	4.5	31	3.9	16–18, 26, 27	4.1	0.6
St. Louis, Mo	1,264	30	11.0	31	3.2	23	4.3	7.8
Chester, Ill	1,189	30	9.0	31	4.4	23–26	5.0	4.6
New Madrid, Mo.	1,003	34	5.4	1	3.7	18–20, 27, 28	4.2	1.7
Memphis, Tenn	843	33	5.6	1	3.5	30,31	4.2	2.1
Helena, Ark.	767	42	6.5	1	3.9	30,31	4.9	2.6
Arkansas City, Ark.	635	42						
Greenville, Miss.	595	42	9.3	31	2.3	25,26	4.9	7.0
Vicksburg, Miss.	474	45	7.8	31	2.0	25–28	3.8	5.8
Natchez, Miss.	373	46	8.6	1	4.9	28,29	6.8	3.7
Baton Rouge, La.	240	35	4.9	1	3.5	30,31	4.2	1.4
Donaldsonville, La	188	28	4.2	1–5	3.3	24	3.7	0.9
New Orleans, La.	108	18	4.8	4,5	3.7	11,25	4.2	1.1
Atchafalaya River.								
Simmesport, La.	127	41	4.5	1, 2, 4–11	0.4	31	2.9	4.1
Melville, La.	103	37	8.4	6–9	5.0	29,30	7.0	3.4
Morgan City, La.(b)	19	8	4.6	5,17	3.0	9,10	4.0	1.6
Hudson River.								
Troy, N. Y.	154	14	3.7	2,10,29	1.5	20	2.9	2.2
Albany, N. Y.	147	12	4.0	27,28	0.4	20	2.4	3.6
Delaware River.								
Hancock (E. Branch), N. Y.	287	12	5.2	29	2.5	24–26	2.9	2.7
Hancock (W. Branch), N. Y.	287	10	4.0	30	2.2	19	2.6	1.8
Port Jervis, N. Y.	215	14	4.4	30	1.1	20–26	1.7	3.3
Phillipsburg, N. J.	146	26	3.8	31	0.0	21–26	0.7	3.8
Trenton, N. J.	92	18	3.0	30,31	0.3	17, 18, 23–26	0.9	2.7
North Branch Susquehanna.								
Binghamton, N. Y.	183	14	2.3	31	1.6	14–16, 18, 25	1.8	0.7
Wilkes-Barre, Pa.	60	17	2.9	30,31	2.1	9–11, 22–26	2.3	0.8
West Branch Susquehanna.								
Williamsport, Pa.	39	20	1.4	27	0.3	4, 5, 8–10, 16–25	0.5	1.1
Susquehanna River.								
Harrisburg, Pa.	69	17	1.6	29	0.4	8–10, 20–24	0.7	1.2
Shenandoah River.								
Riverton, Va.	58	22	2.6	29	–1.2	5–10, 17–24	–0.6	3.8
Potomac River.								
Cumberland, Md.	290	8	2.6	28–31	1.6	1–25	1.8	1.0
Harpers Ferry, W. Va.	172	18	2.0	25,26	–0.6	8–10, 20–24	0.0	2.6
James River.								
Lynchburg, Va.	260	20	5.1	30	0.4	15–23	1.1	4.7
Columbia, Va.	167	18	10.8	31	3.3	23	4.9	7.5
Richmond, Va.	111	10	3.7	31	–0.2	21–23	0.5	3.9
Dan River.								
Danville, Va	55	8	2.6	30	–0.2	6–9	0.4	2.8
Roanoke River.								
Clarksville, Va	196	12	5.2	31	–0.1	10	1.0	5.3
Weldon, N. C.	129	30	24.5	31	10.1	7	12.0	14.4
Tar River.								
Greenville, N. C.	21	22	6.4	30,31	3.7	20	4.6	2.7
Deep River.								
Moncure, N. C.	171	25	11.2	30	7.5	28	8.2	3.7
Cape Fear River.								
Fayetteville, N. C	112	38	17.0	31	3.4	21	5.0	13.6
Pedee River.								
Cheraw, S. C.	149	27	24.4	25,31	1.6	9	8.1	22.8
Smiths Mills, S. C.	51	16	12.9	31	4.2	1	7.9	8.7
Lynch Creek.								
Effingham, S. C.	35	12	5.5	31	3.3	15,16	4.1	2.2
Black River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Kingstree, S. C.	45	12	1.0	31	0.0	18,22	0.2	1.0
Catawba-Wateree River.								
Mount Holly, N. C.	143	15	8.0	24	1.8	1–9, 14–22, 28	2.4	6.2
Catawba, S. C	107	11	12.7	25	1.3	4	3.9	11.4
Camden, S. C.	37	24	26.3	26	6.0	20	11.4	20.3
Congaree River.								
Columbia, S. C	52	15	9.5	30	1.6	5,6	3.0	7.9
Santee River.								
Ferguson, S. C.	82	12	12.6	31	6.5	7,8	9.1	6.1
Savannah River.								
Calhoun Falls, S. C.	347	15	5.0	30	1.9	13, 14, 22	2.6	3.1
Augusta, Ga.	268	32	16.0	30	7.5	22	8.9	8.5
Oconee River.								
Dublin, Ga	79	30	5.3	31	–0.2	6–8	0.6	5.5
Ocmulgee River.								
Macon, Ga.	134	18	5.2	31	1.7	6	2.5	3.5
Abbeville, Ga.	51	11	3.0	14,15	1.4	9	2.0	1.6
Flint River.								
Montezuma, Ga.	152	20	4.0	12	2.2	8	2.9	1.8
Albany, Ga.	99	20	1.6	1	0.6	18–20, 23–27	0.9	1.0
Bainbridge, Ga.	22	22	5.9	15	4.6	21–30	4.9	1.3
Chattahoochee River.								
West Point, Ga	174	20	3.9	13	1.7	1, 3–8	2.2	2.2
Eufaula, Ala	90	40	6.0	30	0.5	4–8	2.0	5.5
Alaga, Ala.	30	25	5.0	15	2.1	6	2.9	2.9
Coosa River.								
Rome, Ga.	266	30	4.0	10	0.0	7	0.7	4.0
Gadsden, Ala.	162	22	3.7	12	0.2	2–9	0.7	3.5
Lock No. 4, Ala.	113	17	2.8	12	0.1	2–8	0.4	2.7
Wetumpka, Ala	12	45	4.1	14,15	0.7	8	1.4	3.4
Alabama River.								
Montgomery, Ala.	323	35	2.3	15	–0.4	7,8	0.2	2.7
Selma, Ala	246	35	1.9	16	–0.9	6–8	–0.3	2.8
Black Warrior River.								
Tuscaloosa, Ala.	90	43	4.7	10–16, 29	4.5	6–8, 24	4.6	0.2
Tombigbee River.								
Columbus, Miss	316	33	–2.9	1	–3.2	6–31	–3.2	0.3
Demopolis, Ala.	168	35	–0.3	1	–2.6	7	–1.8	2.3
Pascagoula River.								
Merrill, Miss.	78	20	2.2	1	0.5	21,23	0.9	1.7
Pearl River.								
Columbia, Miss.	110	18	3.5	1,2	2.8	25–31	3.0	0.7
Sabine River.								
Logansport, La.	315	25	7.6	1	1.6	27–29	3.5	6.0
Neches River.								
Beaumont, Tex.	18	10	2.4	23	0.9	30	1.4	1.5
Trinity River.								
Dallas, Tex.	320	25	28.1	26	4.1	13,18	9.3	24.0
Long Lake, Tex.	211	35	23.1	31	2.2	23	7.3	20.9
Liberty, Tex	20	25	8.2	2	4.7	25	6.1	3.5
Brazos River.								
Waco, Tex.	285	22	6.1	30	1.8	19–21	2.7	4.3
Hempstead, Tex	140	40	4.6	1	0.8	12	2.4	3.8
Booth, Tex	61	39	5.8	28	4.4	10–13, 31	4.9	1.4
Colorado River.								
Austin, Tex	214	18	4.8	26	1.4	19–22	2.1	3.4
Columbus, Tex.	98	24	11.5	29	6.1	25	7.1	5.4
Red River of the North.								
Moorhead, Minn	284	26	8.3	2,3	7.8	16, 17, 24–27	8.0	0.5
Snake River.								
Lewiston, Idaho	144	24	3.0	15,17,18	1.3	2–4	2.1	1.7
Riparia, Wash.	67	30	4.3	25, 27, 29–31	1.8	1	3.2	2.5
Columbia River.								
Wenatchee, Wash	478	40	8.7	1	6.3	29–31	7.3	2.4
Umatilla, Oreg	270	25	3.6	1,17	2.5	29–31	2.9	1.1
The Dalles, Oreg.	166	40	4.5	1,2	2.6	27,30	3.3	1.9
Willamette River.								
Portland, Oreg.	12	15	4.1	10	1.5	4,5	2.4	2.6
Sacramento River.								
Red Bluff, Cal.	265	23	3.0	15	0.6	1–13	0.9	2.4
Colusa, Cal.	156	28	4.3	17	2.0	1–4	2.6	2.3
Knights Landing, Cal.	99	18	3.0	18	0.2	1–5	1.0	2.8
Sacramento, Cal.	64	25	8.3	17	5.3	1–6	5.9	3.0
San Joaquin River.								
Pollasky, Cal.	203	10	0.0	1–31	0.0	1–31	0.0	0.0
Firebaugh, Cal	148	14	0.5	21	–1.4	11–18	–1.1	1.9
Lathrop, Cal.	49	14	1.2	19	0.0	1, 11–15, 17, 18	0.3	1.2

* On various dates. (a) Zero of gage lowered 6.5 feet on October 1, 1908. (b) 17 days only.

Honolulu, T. H., latitude 21° 19′ north, longitude 157° 52′ west; barometer above sea, 38 feet; gravity correction, —0.057 inch, applied. October, 1908.

Day.	Pressure, in inches.* 8 a. m.	Pressure, in inches.* 8 p. m.	Air temperature, degrees Fahrenheit. 8 a. m.	Air temperature 8 p. m.	Maximum.	Minimum.	Moisture. 8 a. m. Wet.	Moisture. 8 a. m. Relative humidity.	Moisture. 8 p. m. Wet.	Moisture. 8 p. m. Relative humidity.	Wind, in miles per hour. 8 a. m. Direction.	Wind 8 a. m. Velocity.	Wind 8 p. m. Direction.	Wind 8 p. m. Velocity.	Precipitation, inches. 8 a. m.	Precipitation, inches. 8 p. m.	Clouds. 8 a. m. Amount.	Clouds. 8 a. m. Kind.	Clouds. 8 a. m. Direction, from.	Clouds. 8 p. m. Amount.	Clouds. 8 p. m. Kind.	Clouds. 8 p. m. Direction, from.
							°	%	°	%												
1	30.09	30.07	79.0	76.0	82	73	71.0	68	68.0	66	e.	3	e.	9	......	......	3	Cu.	ne.	Few	Cu.	ne.
2	30.03	29.98	77.2	75.0	82	72	67.1	59	67.0	66	n.	4	n.	5	......	......	Few	Cu.	ne.	1 2	A.-s. Cu.	n. e.
3	29.97	29.95	73.4	75.0	81	69	67.2	72	66.0	62	e.	4	e.	7	0.05	......	4	Cu.	ne.	2	Cu.	ne.
4	30.02	30.03	75.0	73.8	81	72	69.0	74	68.0	75	e.	4	e.	4	T.	T.	4 3	A.-cu. Cu.	s. ne.	10	n.	e.
5	30.04	30.03	76.0	75.0	80	72	69.0	70	69.0	74	e.	5	e.	2	0.01	......	10	A.-s.	se.	1 9	Cu. S.	e. e.
6	30.00	30.00	75.4	72.0	79	71	70.0	76	70.0	91	ne.	8	se.	2	......	0.02	10	S.	0	9	S.-cu.	ne.
7	29.98	29.95	75.2	74.0	80	73	68.3	70	68.0	74	ne.	11	ne.	6	......	......	9 Few	A.-cu. Cu.	w. 0	1 3	A.-s. Cu.	n. e.
8	29.96	29.98	77.0	74.5	82	70	68.2	63	68.0	72	n.	2	ne.	2	......	......	Few	Cu.	e.	Few	Cu.	e.
9	30.00	29.98	77.6	75.5	83	70	69.1	65	70.0	76	sw.	1	n.	3	......	......	Few	Cu. Lt. haze.	0	10	Cu.	ne.
10	30.02	30.01	77.2	75.0	83	69	69.0	66	70.0	78	ne.	1	e.	2	......	......	Few	Cu. Lt. smoke	0	10 Few	Ci.-s. Cu.	sw. e.
11	30.01	29.99	78.0	75.0	85	70	69.2	64	69.0	74	se.	2	ne.	2	......	......	Few	A.-s.	0	1 1	A.-s. Cu.	0 0
12	29.99	30.02	75.4	75.5	84	70	68.0	68	70.0	76	sw.	1	se.	3	......	......	......	Lt. haze.	....	Few Few	A.-s. Cu.	0 0
13	30.05	30.10	80.8	77.0	82	72	72.1	66	70.0	71	e.	3	e.	9	T.	T.	3	Cu.	e.	0	0	0
14	30.11	30.09	79.0	77.0	82	75	69.1	60	69.0	67	e.	14	ne.	15	T.	......	1 8	Ci.-s. Cu.	0 e.	5	S.	ne.
15	30.09	30.06	76.0	76.0	79	74	68.8	69	68.0	66	e.	12	ne.	20	......	T.	9	S.-cu.	e.	9	S.	e.
16	30.03	30.03	76.0	76.0	78	75	66.4	61	68.0	66	e.	17	e.	18	......	......	10	S.	se.	8	Cu.	e.
17	30.05	30.06	78.2	76.0	82	75	69.0	63	68.0	66	e.	13	e.	7	......	......	5 2	Ci.-cu. Cu.-s.	0 e.	2	Cu.	ne.
18	30.07	30.04	72.0	74.5	80	70	69.0	86	67.0	68	e.	9	e.	6	0.01	0.02	10	N.	e.	0	0	0
19	30.00	29.99	74.0	74.0	81	71	69.0	78	68.0	74	e.	2	e.	4	0.02	......	6 2	A.-cu. Cu.	e. e.	0	0	0
20	29.99	29.96	77.0	75.2	81	68	68.0	63	69.0	73	ne.	8	e.	3	0.07	......	1	A.-cu.	0	0	0	0
21	29.98	29.98	77.4	75.0	81	74	68.0	62	66.0	62	ne.	13	e.	5	......	......	Few	Cu.	0	0	0	0
22	30.00	29.90	76.0	76.0	81	73	66.8	62	67.0	62	e.	5	e.	12	......	......	4	Cu.	e.	2	Cu.	e.
23	30.04	30.01	77.0	74.5	80	72	68.0	63	67.0	68	e.	8	ne.	9	T.	......	3	Cu.	n.	0	0	0
24	30.00	29.96	74.5	73.0	81	70	67.1	68	66.0	69	e.	4	ne.	10	0.02	......	9	S.-cu.	e.	0	0	0
25	29.94	29.92	75.0	73.0	79	71	64.5	56	67.0	73	ne.	4	ne.	4	T.	T.	5	Cu.	ne.	5	S.	e.
26	29.93	29.94	75.5	73.0	79	69	67.0	64	67.0	73	n.	2	ne.	3	......	......	3	Cu.	e.	0	0	0
27	29.95	29.96	77.2	73.0	80	70	68.0	62	68.0	78	ne.	5	e.	3	......	......	5	Cu.	e.	0	0	0
28	29.96	29.95	77.0	74.5	81	70	68.0	63	68.0	72	e.	3	se.	2	......	......	1 1	Ci.-s. Cu.	0 e.	0	0	0
29	29.97	29.98	77.6	74.0	81	71	66.7	56	67.0	69	e.	10	e.	3	......	......	Few Few	Ci.-cu. Cu.	0 0	4 1	A.-cu, A.-s.	nw. 0 ?
30	30.02	29.99	77.2	74.0	80	70	67.3	60	68.0	74	e.	4	ne.	10	......	......	3	Cu.	e.	1 3	A.-s. Cu.	0 e.
31	29.99	29.99	77.0	73.5	80	71	67.1	59	66.5	69	n.	3	e.	6	......	......	1	Cu. Lt. haze.	e.	1	Cu.	ne.
Mean....	30.009	30.000	76.5	74.7	81.0	71.4	68.2	65.7	68.0	71.1	e.	5.8	e.	6.3	0.18	0.04	4.4	Cu.	e.	3.3	Cu.	e.

Observations are made at 8 a.m. and 8 p. m., local standard time, which is that of 157° 30′ west, and is 5h and 30m slower than 75th meridian time. *Pressure values are reduced to sea level and standard gravity.

Chart I. Hydrographs for Seven Principal Rivers of the United States, October, 1908.

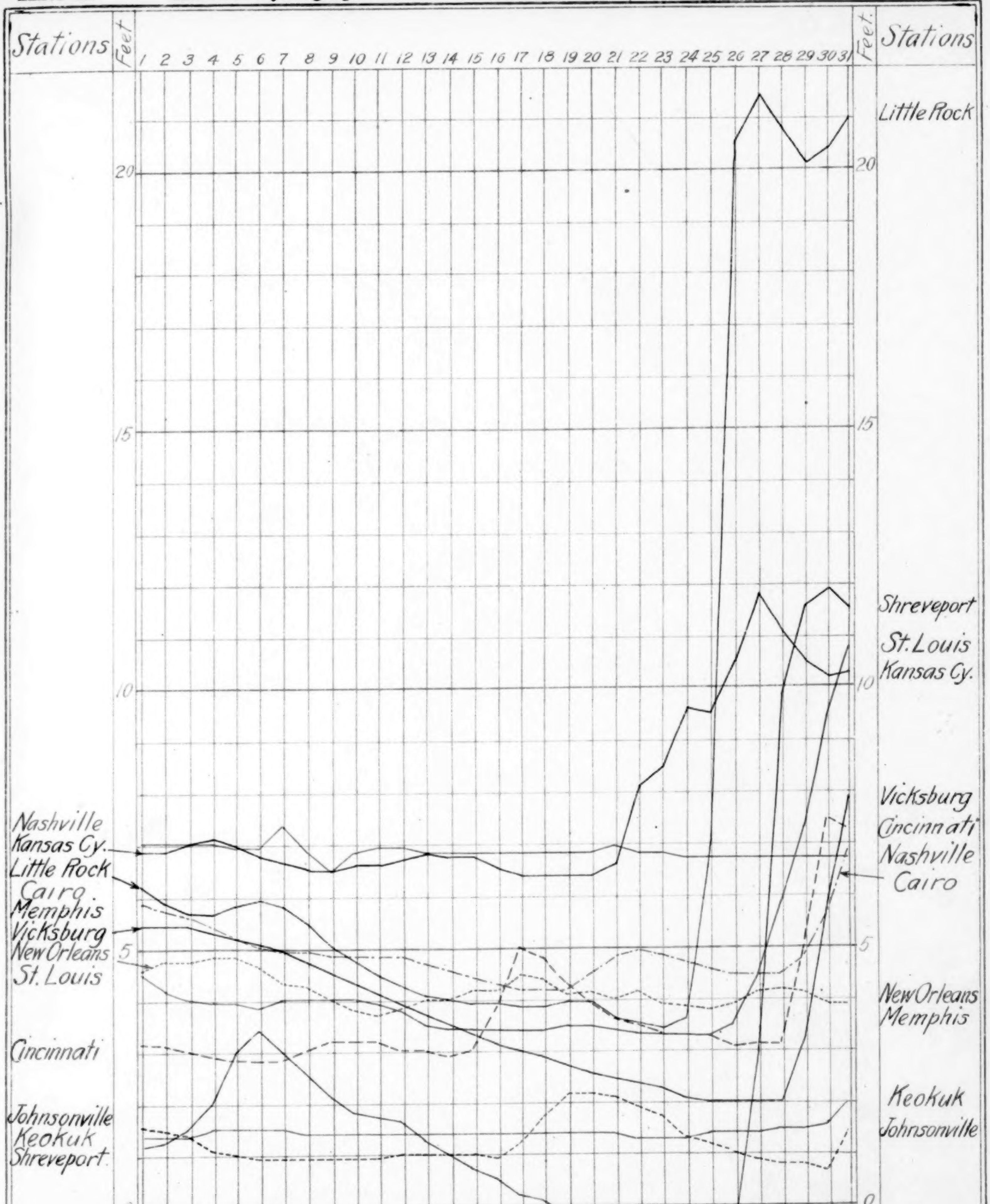

Chart II. Tracks of Centers of High Areas, October, 1908.

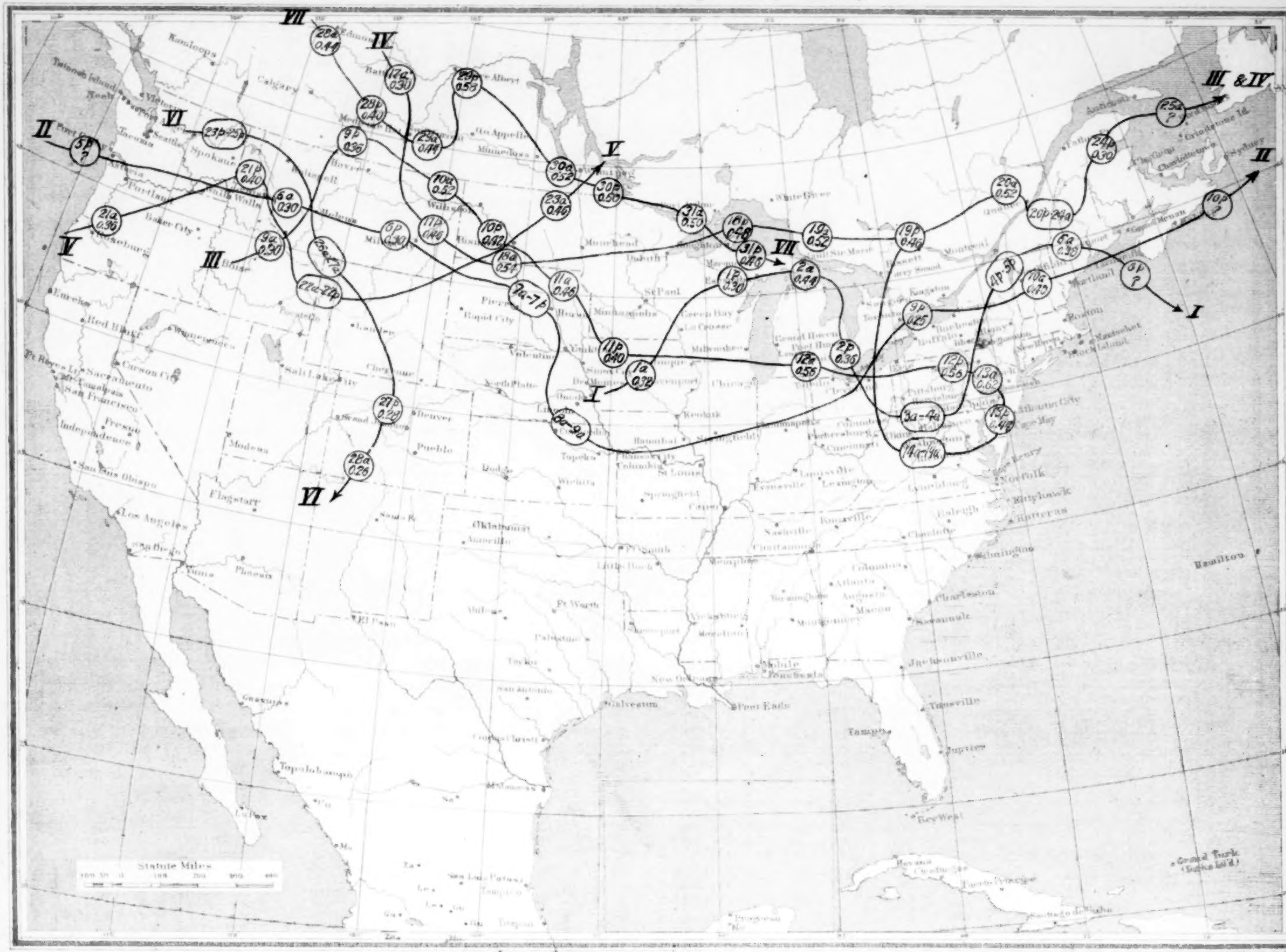

Chart III. Tracks of Centers of Low Areas, October, 1908.

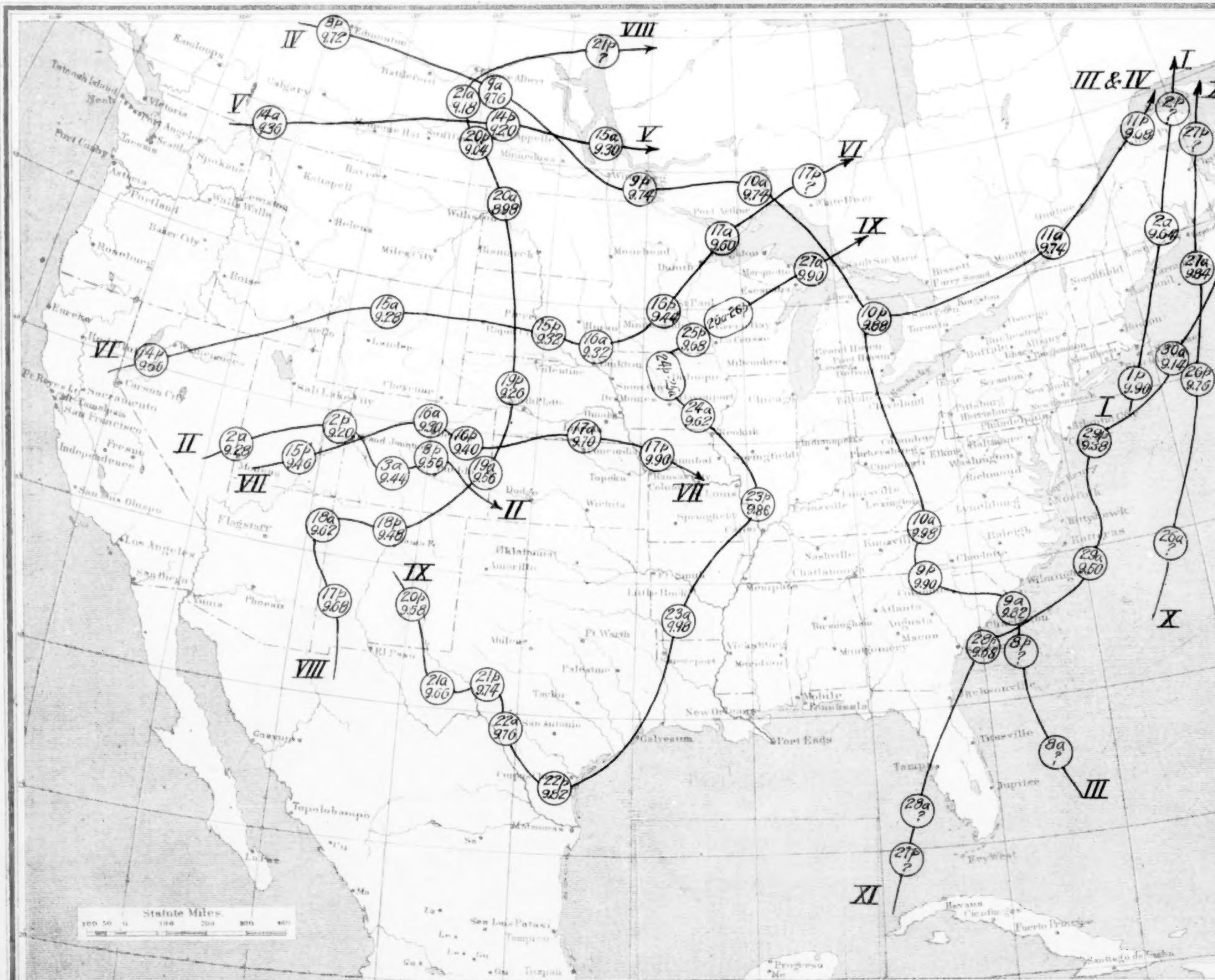

Chart IV. Total Precipitation, October, 1908.

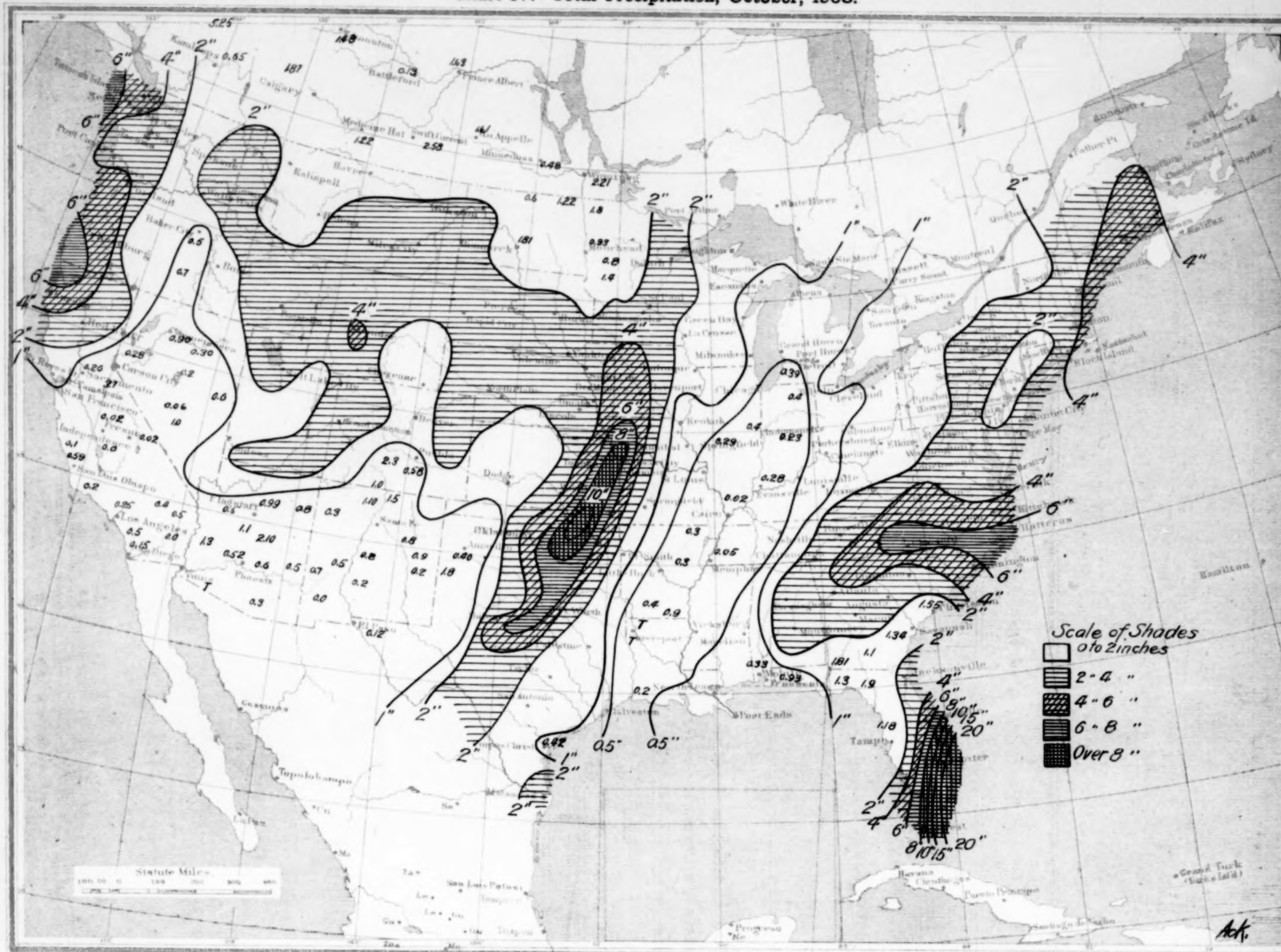

Chart V. Percentage of Clear Sky between Sunrise and Sunset, October, 1908.

Chart V. Percentage of Clear Sky between Sunrise and Sunset, October, 1908.

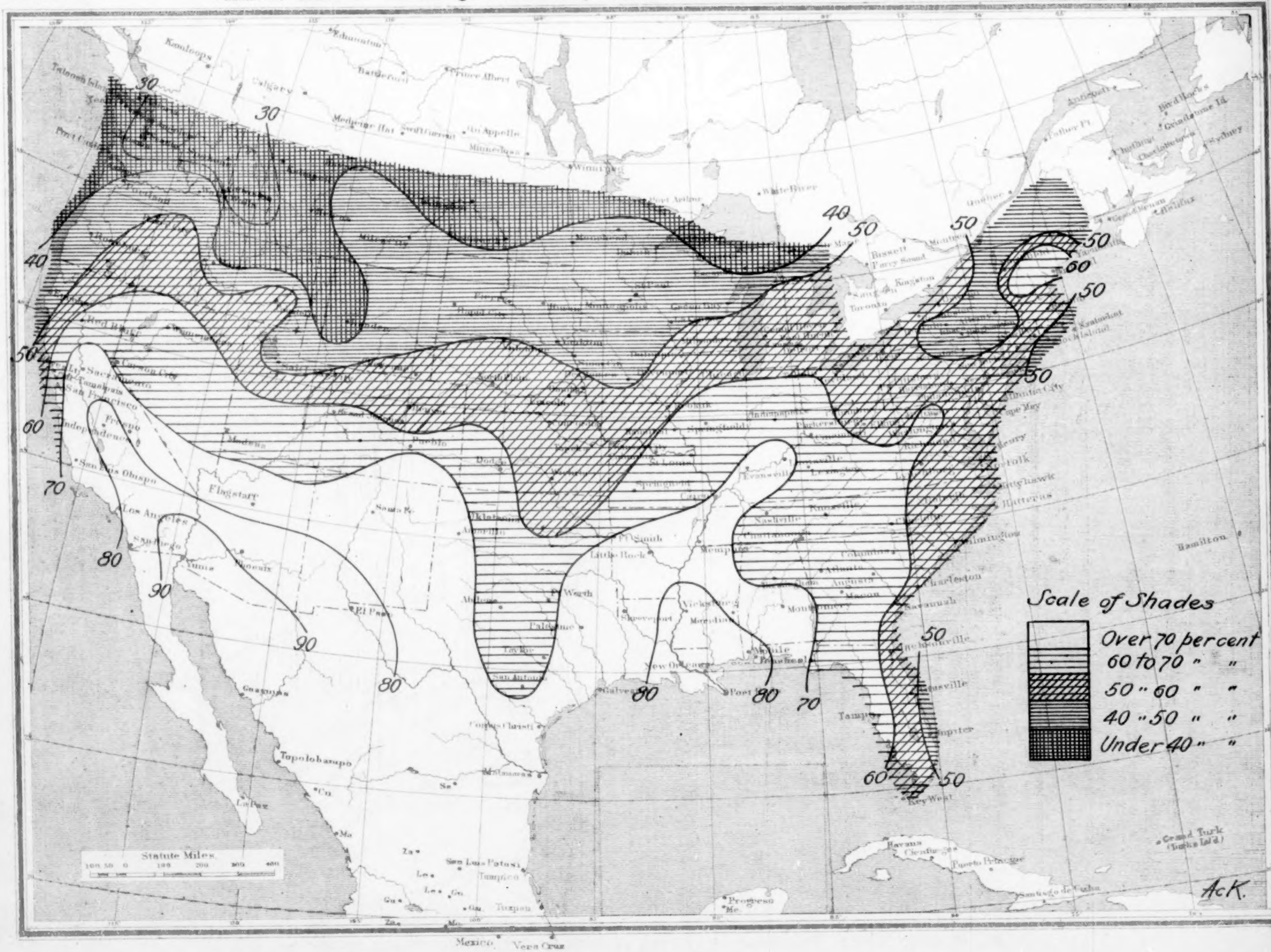

Chart VI. Isobars and Isotherms at Sea Level; Prevailing Winds, October, 1908.

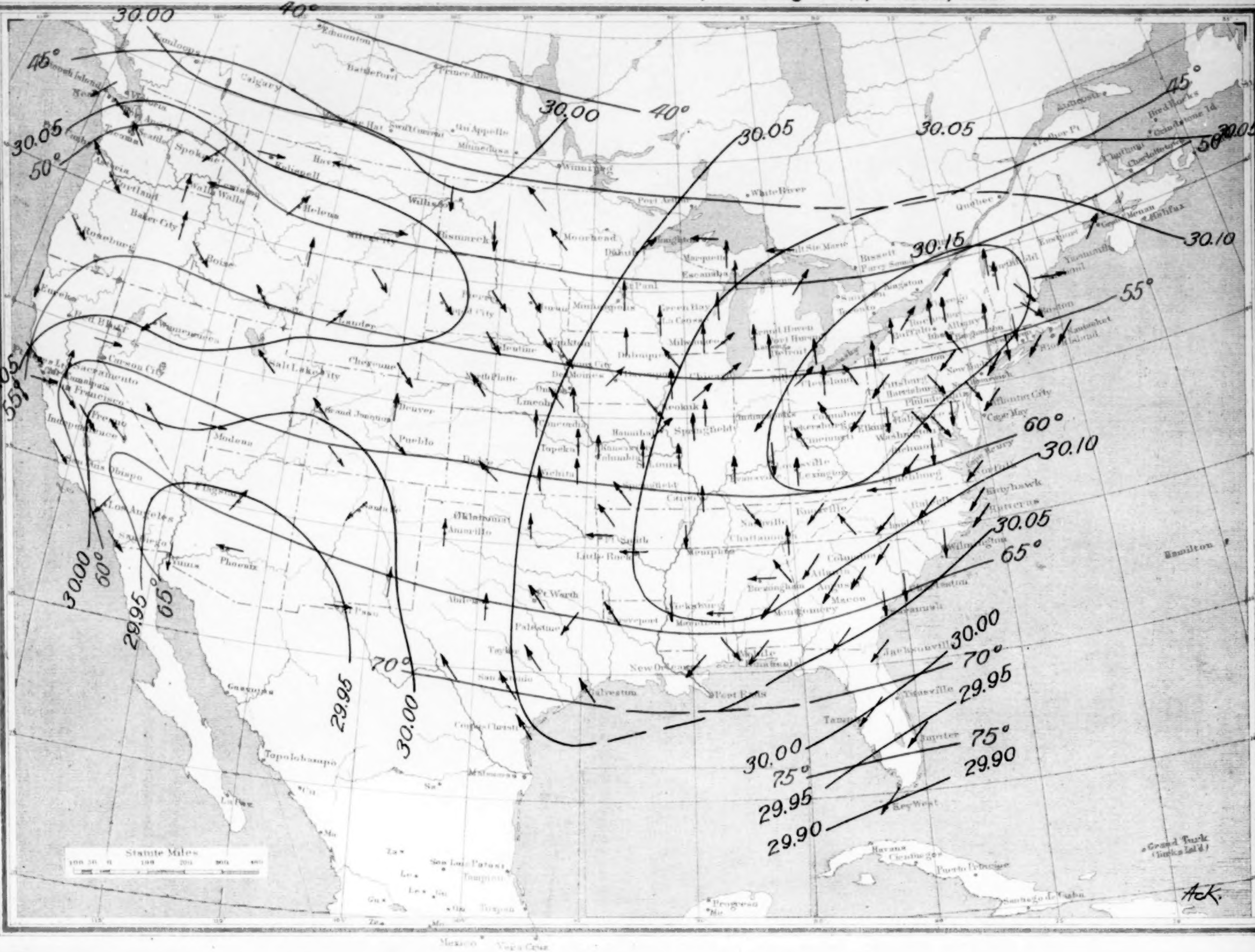

Chart VII. Total Snowfall for October, 1908.

Chart VII. Total Snowfall for October, 1908.

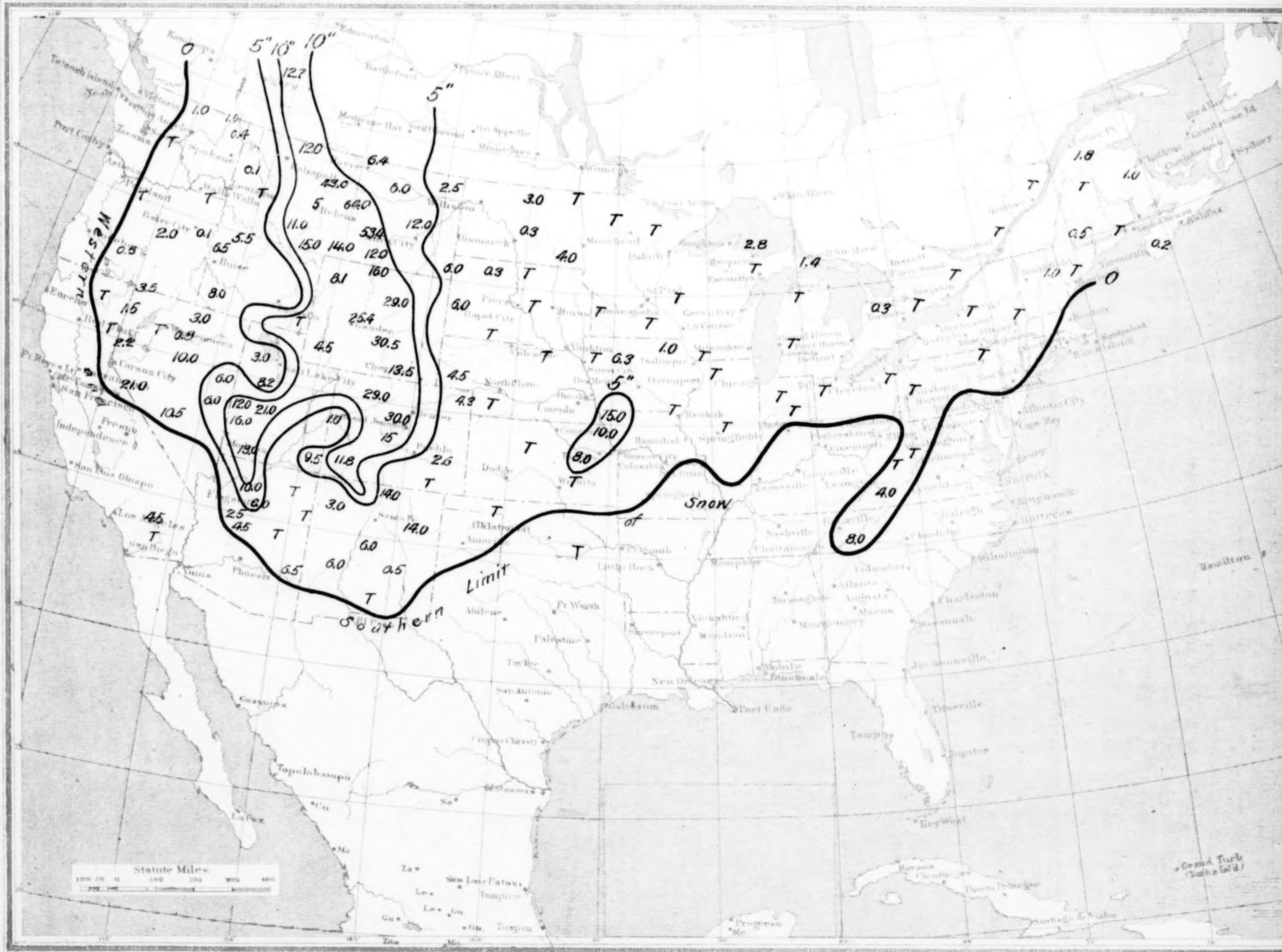

Chart IX.

Isobars of the DeWitte typhoon of August 1-3, 1901, after Rev. Louis Froc, S. J., Zi-ka-wei Observatory.

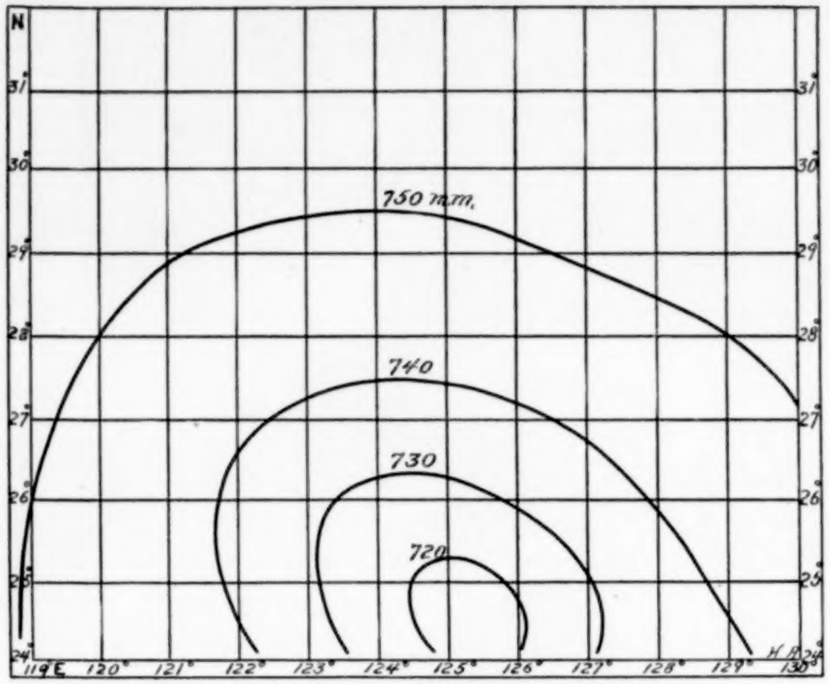

FIG. 9.—Sea-level isobars of August 2, 1901, at 10 a. m.

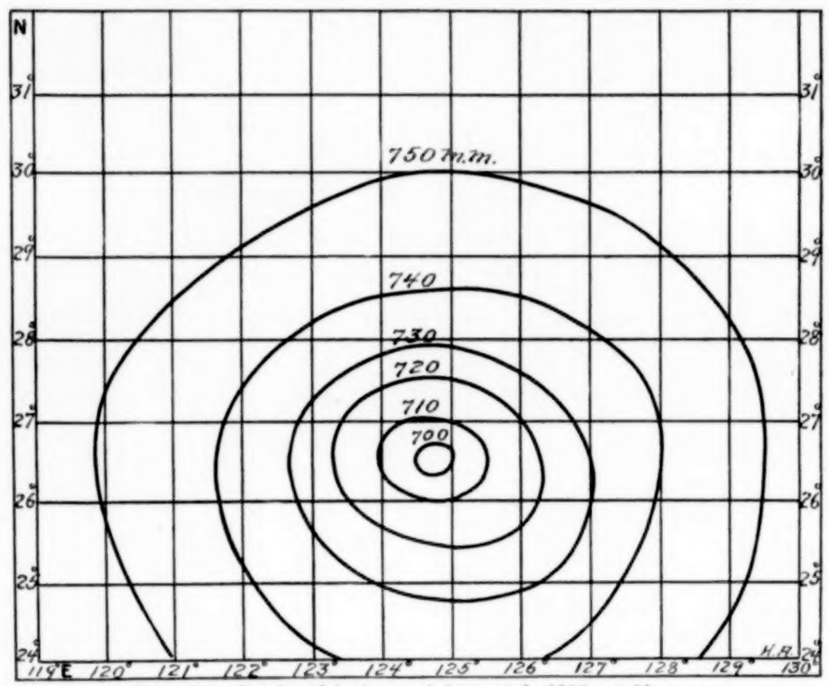

FIG. 10.—Sea-level isobars of August 2, 1901, at 10 p. m.

Composites of the DeWitte typhoon of August 1-3, 1901, plotted on the adopted isobars of August 2, 1901, at 10 p. m.

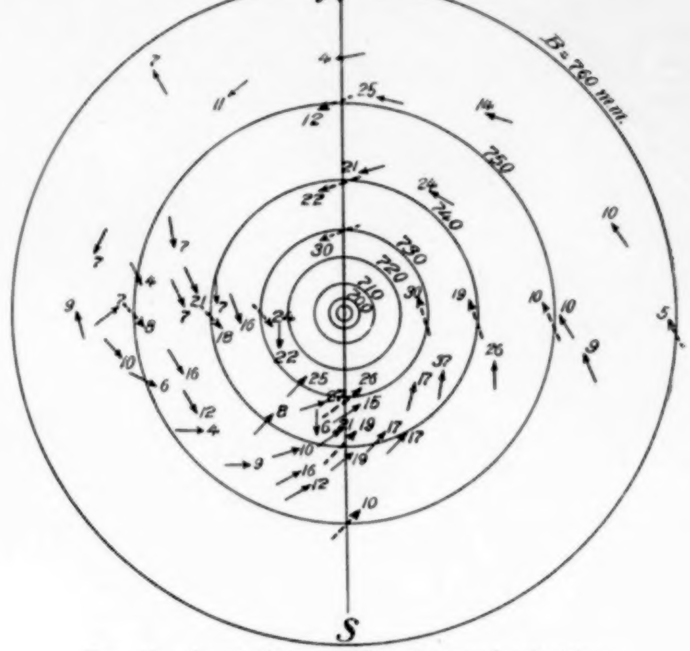

FIG. 12.—Composite wind directions and velocities.

FIG. 13.—Composite temperature distribution.

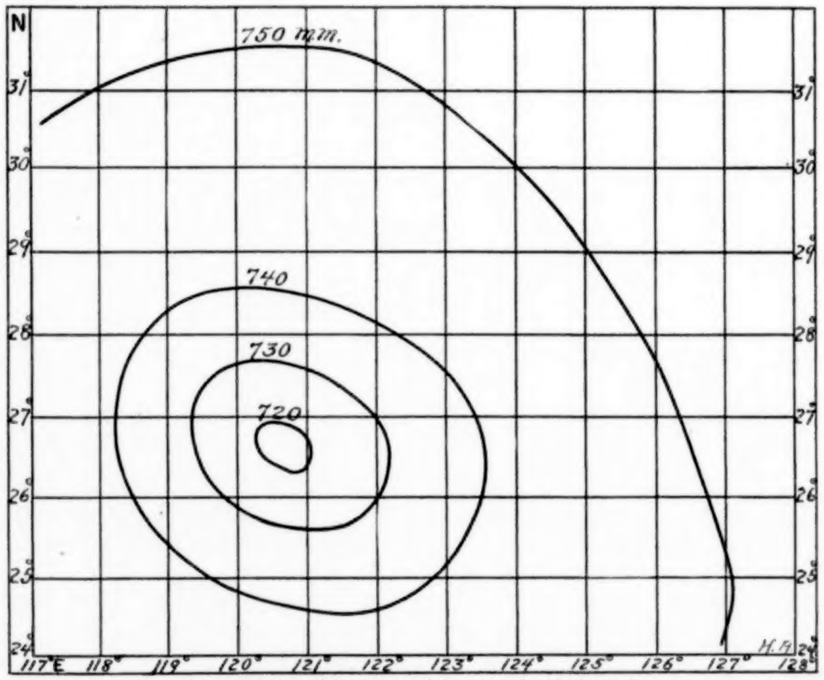

Fig. 11.—Sea-level isobars of August 3, 1901, at 5 a. m.

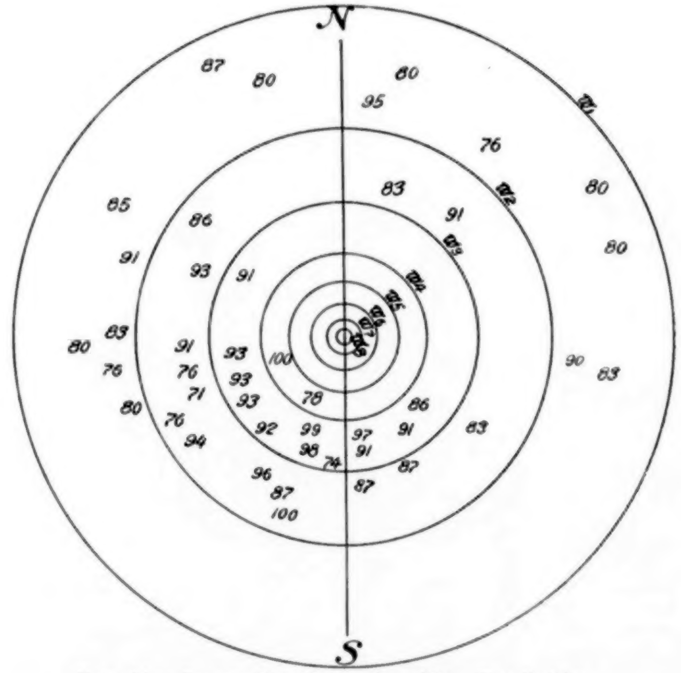

Fig. 14.—Composite relative humidity distribution.

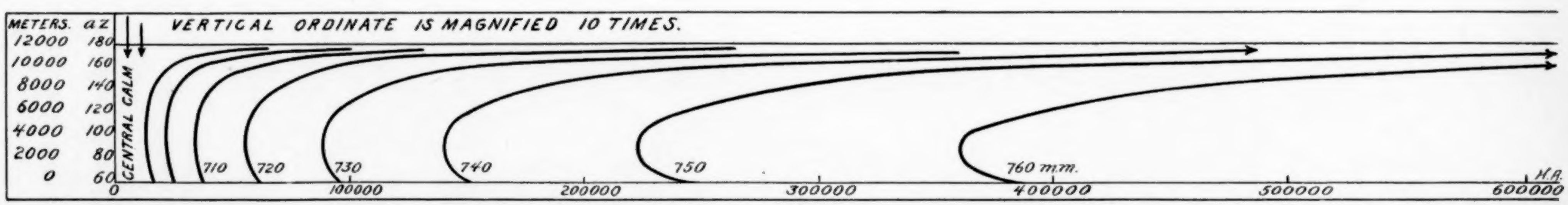

Fig. 15.—Vertical section thru one-half of the DeWitte typhoon, August 1-3, 1901, showing the vortex tubes.